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Proximate and Phytochemical Composition of Ethanolic Extracts from *Chromolaena odorata* and *Zingiber officinale*

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Abstract

This study evaluated the proximate and phytochemical composition of *Chromolaena odorata* (Siam weed) leaves and *Zingiber officinale* (ginger) rhizomes, plants traditionally used in gastrointestinal and ulcer management. Proximate analysis revealed marked nutritional differences: ginger contained higher carbohydrate (64.39%) and moisture (15.96%) levels, while *C. odorata* was richer in ash (14.39%), fat (10.75%), fiber (8.52%), and protein (10.50%). Phytochemical screening identified a wide range of bioactive compounds, including flavonoids, alkaloids, saponins, cardiac glycosides, tannins, phenols, phytates, oxalates, anthocyanins, steroids and cyanogenic glycosides. Quantitative analysis showed that *C. odorata* contained higher alkaloids (16.82%) and saponins (19.27%), whereas ginger exhibited higher steroids (12.69%), phenols (5.04%), and flavonoids (6.51%). Tannin and anthocyanin levels were also greater in ginger (4.29% and 4.28%, respectively) compared to *C. odorata* (1.06% and 2.79%). Both plants contained minimal concentrations of anti-nutritional factors, including phytates (0.70–1.05%), oxalates (0.27–1.06%), and cyanogenic glycosides (0.32–3.19%), indicating safety for therapeutic use. These findings highlight the complementary nutritional and phytochemical profiles of the two species: *C. odorata* offers higher mineral, protein, and saponin content, supporting its traditional wound-healing and anti-inflammatory roles, while ginger is enriched in carbohydrates, flavonoids, phenols, and steroids, underpinning its antioxidant and gastroprotective activities. Collectively, the results suggest that *C. odorata* and ginger provide a robust nutritional and bioactive foundation for ethnomedicine, particularly in gastrointestinal health. Further pharmacological and clinical studies are recommended to validate their synergistic therapeutic potential.

Keywords: *Chromolaena odorata, Zingiber officinale, proximate composition, phytochemicals, ulcer management, medicinal plants.*

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1. Introduction

Medicinal plants have long been a cornerstone of primary healthcare systems, particularly in developing nations where access to conventional pharmaceuticals is often limited by cost, availability, or infrastructure (World Health Organization [WHO], 2023; Akwas *et al*., 2025). The WHO estimates that approximately 80% of the global population relies on plant-based remedies for basic health needs, a practice deeply rooted in traditional knowledge systems across Africa, Asia, and Latin America (WHO, 2023). These plants not only offer therapeutic potential but also serve as dietary sources of essential nutrients, positioning them as vital tools in both preventive and curative health strategies (Egbuna *et al*., 2020). The integration of nutritional and pharmacological benefits in medicinal plants underscores their role as nutraceuticals, bridging the gap between food and medicine (Sofowora *et al*., 2021; Okei and Uwakwe, 2025).

Among the diverse array of medicinal plants, *Chromolaena odorata* (L.) R.M. King & H. Rob. (Asteraceae), commonly

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known as Siam weed, and *Zingiber officinale* Roscoe (Zingiberaceae), widely recognized as ginger, stand out for their ethnomedicinal significance and widespread use. *C. odorata*, a perennial shrub native to the Americas but now distributed across tropical and subtropical regions, is often regarded as an invasive weed due to its rapid proliferation (Oerke, 2022). Despite this, its leaves are extensively used in traditional medicine for wound healing, anti-inflammatory effects, and the management of gastrointestinal disorders, including peptic ulcers (Egbuna *et al*., 2021). Studies have attributed these properties to its rich phytochemical profile, which includes flavonoids, tannins, alkaloids, and saponins, known for their antimicrobial, antioxidant, and hemostatic activities (Akinmoladun *et al*., 2022). The plant's dual role as both a medicinal resource and an ecological challenge has spurred increasing scientific interest in validating its therapeutic claims (Vijayaraghavan *et al*., 2023).

Z. officinale, a rhizomatous perennial herb, is one of the most globally recognized spices, valued for both culinary and medicinal applications (Mao *et al*., 2020). Originating in Southeast Asia, ginger has been used for centuries in traditional systems such as Ayurveda, Traditional Chinese Medicine, and African ethnomedicine to treat ailments including nausea, inflammation, arthritis, and peptic ulcer disease (Shahrajabian *et al*., 2021). Its pharmacological effects are driven by bioactive compounds such as gingerols, shogaols, zingerone, and flavonoids, which exhibit antioxidant, anti-inflammatory, hypoglycemic, and lipid-modulating properties (Kiyama, 2020; Egbuna *et al*., 2020). Recent research has highlighted ginger's potential in managing chronic conditions like diabetes and cardiovascular diseases, reinforcing its nutraceutical value (Li *et al*., 2023). The synergy of these bioactive compounds makes *Z. officinale* a promising candidate for integrative health approaches.

The nutritional and phytochemical profiling of medicinal plants like *C. odorata* and *Z. officinale* is critical for several reasons. Proximate analysis, which quantifies macronutrients such as carbohydrates, proteins, fats, fibers, moisture, and ash, provides insights into their dietary value (Adegbaju *et al*., 2021). For instance, high carbohydrate content can support energy needs, while fiber contributes to digestive health, which is particularly relevant for gastrointestinal disorders like ulcers (Sofowora *et al*., 2021). Phytochemical screening, on the other hand, identifies secondary metabolites—such as flavonoids, tannins, saponins, and phenols—that underpin the therapeutic efficacy of these plants (Egbuna *et al*., 2021). These compounds are known to combat oxidative stress, inhibit microbial growth, and modulate physiological pathways, such as those involved in inflammation and gastric mucosal protection (Alara *et al*., 2022).

Flavonoids, for example, are potent antioxidants that neutralize reactive oxygen species (ROS), reducing oxidative damage in ulcerated tissues (Panche *et al*., 2021). Tannins and saponins contribute to antimicrobial and anti-inflammatory effects, potentially inhibiting pathogens like *Helicobacter pylori*, a key contributor to peptic ulcers (Egbuna *et al*., 2020, Ekesiobi *et al*., 2025; Iheukwumere *et al*., 2025; Ilechukwu *et al*., 2025). Phenols, with their broad-spectrum bioactivity, enhance cellular defense mechanisms, while alkaloids may influence neural and metabolic pathways (Vijayaraghavan *et al*., 2023). Elucidating the presence and concentration of these phytochemicals is vital for understanding the mechanisms underlying the traditional applications of *C. odorata* and *Z. officinale*, in line with recent advances in biomolecule extraction for therapeutic purposes (Okei & Uwakwe, 2025).

Despite the extensive literature on these plants individually, comparative studies analyzing their nutritional and phytochemical profiles side by side are scarce. Such comparisons are valuable for identifying complementary or synergistic properties that could justify their combined use in traditional therapies or inform the development of novel pharmaceutical formulations (Ekesiobi *et al*., 2017; Egbuna *et al*., 2021). For instance, the antioxidant flavonoids in *Z. officinale* may complement the antimicrobial alkaloids in *C. odorata*, potentially enhancing their efficacy in ulcer management (Alara *et al*., 2022). Moreover, nutritional profiling can highlight their role as functional foods, providing both sustenance and therapeutic benefits in resource-limited settings (Adegbaju *et al*., 2021).

The global burden of peptic ulcer disease, estimated to affect 5–10% of the population, underscores the need for accessible and effective treatments (Lanas & Chan, 2022). Conventional therapies, such as proton pump inhibitors and antibiotics, are effective but often associated with side effects like diarrhea, liver toxicity, and antimicrobial resistance (Malfertheiner *et al*., 2023). Herbal medicines offer a promising alternative, particularly in developing nations where plants like *C. odorata* and *Z. officinale* are readily available (WHO, 2023). However, rigorous scientific validation is required to bridge the gap between traditional knowledge and modern pharmacology, ensuring safety and efficacy (Sofowora *et al*., 2021).

Recent studies have emphasized the importance of standardizing herbal extracts to ensure consistent therapeutic outcomes (Egbuna *et al*., 2020; Ekesiobi and Onebunne, 2025). Proximate and phytochemical analyses provide baseline data that can guide standardization efforts, enabling the identification of active compounds and their optimal concentrations (Alara *et al*., 2022). Furthermore, these analyses can inform dosage regimens and delivery methods, such as capsules or infusions, to maximize bioavailability (Panche *et al*., 2021). Patents have also highlighted optimized extraction and characterization processes for bioactive compounds as a pathway to enhancing therapeutic applications (Unegbu *et al*., 2025). The comparative approach adopted in this study addresses a critical gap in the literature by evaluating *C. odorata* and *Z. officinale* together, offering insights into their potential synergistic effects.

Therefore, the present study was designed to evaluate the proximate composition and phytochemical constituents of ethanolic extracts of *Chromolaena odorata* and *Zingiber officinale*. By providing comprehensive data on their nutritional and bioactive components, this work aims to establish a scientific foundation for their therapeutic applications, particularly in the management of chronic gastrointestinal disorders like peptic ulcers. The findings are

expected to contribute to the growing body of evidence supporting the integration of medicinal plants into modern healthcare, particularly in resource-constrained settings where such plants are a vital health resource.

2. Materials and Methods

2.1 Plant Materials and Preparation

Fresh leaves of Chromolaena odorata were collected from Mgbakwu Farm, Anambra State, Nigeria, while rhizomes of Zingiber officinale were obtained from Eke Awka Market. The plant materials were authenticated by a botanist at Chukwuemeka Odumegwu Ojukwu University, Uli. Samples were washed, air-dried at room temperature, pulverized into fine powder, and stored in airtight containers until analysis.

2.2 Proximate Composition Analysis

2.2.1 Moisture Content (AOAC, 2001)

Principle: Moisture content is determined by oven-drying the sample at 105 °C until a constant weight is achieved.

Procedure: A clean, dry Petri dish was weighed, and approximately 2 g of the sample was introduced. The combined weight was recorded before drying (W1). The dish and sample were dried at 105 °C for 2 hours, cooled in a desiccator, and reweighed (W2). Heating, cooling, and weighing continued until a constant weight was obtained.

Calculation: % Moisture = (W1 – W2) / Weight of sample × 100

2.2.2 Ash Content (AOAC, 2001)

Principle: Ash is the inorganic residue remaining after the combustion of organic matter.

Procedure: A clean platinum crucible was weighed (W1) and loaded with 1–2 g of sample. The crucible and sample were weighed (W2), then incinerated in a muffle furnace at 550 °C for 3 hours. The crucible with ash was cooled and reweighed (W3).

Calculation: % Ash = (W3 – W1) / (W2 – W1) × 100

2.2.3 Crude Fat (Soxhlet Extraction Method)

Principle: Fat is extracted from dried samples using petroleum ether in a Soxhlet extractor.

Procedure: Clean boiling flasks were dried, weighed, and filled with 300 ml petroleum ether (40–60 °C). Samples in thimbles were extracted for 6 hours under reflux. After extraction, the solvent was recovered and the flask dried at 105–110 °C, cooled, and reweighed.

Calculation: % Fat = (Weight of flask + oil – Weight of flask) / Weight of sample × 100

2.2.4 Crude Fibre

Principle: Crude fibre is the organic residue remaining after sequential treatment with dilute acid and alkali.

Procedure: Two grams of defatted sample were boiled under reflux for 30 minutes in 200 ml of 1.25% H_2SO_4. The mixture was filtered, washed until neutral, and boiled again in 200 ml of 1.25% NaOH for 30 minutes. The residue was filtered through a Gooch crucible with asbestos, dried, weighed, incinerated, cooled, and reweighed.

Calculation: % Crude Fibre = Weight of fibre / Weight of sample × 100

2.2.5 Crude Protein (Kjeldahl Method, AOAC, 2001)

Principle: Nitrogen in the sample is digested with H_2SO_4 and a catalyst, converted to ammonium sulfate, distilled, and titrated to determine nitrogen content. Protein is calculated as % N × 6.25.

Procedure: 0.5 g of sample was digested with concentrated H_2SO_4 and catalyst until clear, diluted to 100 ml, and distilled with NaOH. Ammonia was trapped in boric acid with indicators and titrated against 0.01 N HCl.

Calculations:
% N = Titre × 0.01 × 14 × 4
% Protein = % N × 6.25

2.2.6 Carbohydrate (By Difference)

Carbohydrate was determined by difference:

% Carbohydrate = 100 – (% Protein + % Moisture + % Ash + % Fat + % Fibre)

2.3 Phytochemical Analysis

2.3.1 Flavonoids Determination

The total flavonoid content was determined gravimetrically following standard procedures. Five grams of air-dried, powdered sample was first defatted with petroleum ether and then extracted with 70% methanol by refluxing. The extract was concentrated and hydrolyzed with 10% HCl under reflux for 30 minutes to liberate flavonoid aglycones. After cooling, the hydrolysate was neutralized with sodium bicarbonate solution and partitioned with ethyl acetate in a separatory funnel. The combined ethyl acetate fractions were washed with distilled water, dried over anhydrous sodium sulfate, and filtered. The filtrate was evaporated to dryness in a pre-weighed dish, and the residue was further dried at 40–50 °C to constant weight, cooled in a desiccator, and reweighed. The increase in weight represented the total flavonoid content, which was expressed as a percentage of the sample's dry weight (Harborne, 1998; Edeoga *et al*., 2005).

2.3.2 Alkaloid Determination

The total alkaloid content was determined using the gravimetric method as described by Harborne (1998) and later applied by Edeoga, Okwu, and Mbaebie (2005). Five grams of the powdered sample was defatted with petroleum ether and extracted with 10% acetic acid in ethanol for 4 hours. The mixture was filtered and the extract concentrated on a water bath to one-quarter of its original volume. Concentrated ammonium hydroxide was then added dropwise to the concentrated extract until complete precipitation occurred. The precipitate was collected by filtration, washed with dilute ammonium hydroxide, and dried to constant weight in an oven at 40–50 °C. The dried residue was weighed, and the increase

in weight was taken as the total alkaloid content, expressed as a percentage of the sample's dry weight (Harborne, 1998; Edeoga *et al.*, 2005).

2.3.3 Determination of Saponin

Exactly 5g of the sample was put into 20% acetic acid in ethanol and allowed to stand in a water-bath at 50^0c for 24hours. This was filtered and the extract was concentrated using a water-bath to one-quarter of the original volume. Concentrated NH_4OH was added drop-wise to the extract until the precipitate was complete. The whole solution was allowed to settle and the precipitate was collected by filtration and weighed. The saponin content was weighed and calculated in percentage (Obadoni and Ochuko, 2001).

Calculation:

$$\%\ \text{Saponin content} = \frac{(\text{weight of filter paper} + \text{residue}) - (\text{weight of filter paper})}{\text{Weight of sample analyzed}} x100$$

2.3.4 Cardiac Glycosides Determination

Wag and Filled method was used. To 1ml of extract was adde5d 1ml of 2% solution of 3,5-DNS (Dinitro Salicylic acid) in methanol and 1ml of 5% aqueous NaOH. It was boiled for 2 minutes (until brick-red precipitate was observed) and the boiled sample was filtered. The weight of the filter paper was weighed before filtration. The filter paper with the absorbed residue was dried in an oven at 50^0c till dryness and weight of the filter paper with residue was noted.

The cardiac glycoside was calculated in %.

Calculation:

$$\%\ \%\ \text{Cardiac glycoside} = \frac{(\text{weight of filter paper} + \text{residue}) - (\text{weight of filter paper})}{\text{Weight of sample analyzed}} x100$$

2.3.5 Phytate Determination

Phytate contents were determined using the method of Young and Greaves (1940) as adopted by Lucas Markakes (1975). 0.2g of each of the differently processed corns was weighed into different 250ml conical flasks. Each sample was soaked in 100ml of 2% concentrated HCL for 3hr, the sample was then filtered. 50ml of each filtrate was laced in 250ml beaker and 100ml distilled water added to each sample. 10ml of 0.3% ammonium thiocynate solution was added as indicator and titrated with standard iron (111) chloride solution which contained 0.00195g iron per 1ml.

$$\text{Phytic acid} = \frac{\text{Titre value x } 0.00195 \text{ x } 1.19}{\text{Wt of sample}}$$

2.3.6 Cynogenic Glycoside by Acid Titration Method

Place 10 -20 sample, ground to pass N0.20 sieve, in 800ml kjeldahl flask, add 100ml H_2O. Macedrate at room temperature for 2hours. Add 100ml of H_2O and steam distill, collecting distillate in 20ml 0.02N $AgNO_3$ acidified with 1ml HNO_3. Before distillation adjusts appropriately, so that tip of condenser dips below surface of liquid in receiver. When 150ml has passed over, filter distillate through gooch wash receiver and gooch with little H_2O.Titrate excess $AgNO_3$ in combined filtrate and washings with 0.02N KCN, using Fe alum indicator. 1ml 0.02N $AgNO_3$ = 0.54mg HCN.

2.3.7 Tannin Determination by Follins dennis Titration

The follins dennis titrating method as described by Pearson (1974) was used. To 20g of the crushed sample in a conical flask was added 100mls of petroleum ether and covered for 24 hours. The sample was then filtered and allowed to stand for 15 minutes allowing petroleum ether to evaporate. It was then re-extracted by soaking in 100ml of 10% acetic acid in ethanol for 4hrs. The sample was then filtered and the filter ate collected. 25ml of NH_4OH were added to the filterate to precipitate the alkaloids. The alkaloids were heated with electric hot plate to remove some of the NH_4OH still in solution. The remaining volume was measured to be 33ml. 5ml of this was taken and 20ml of ethanol was added to it. It was titrated with 0.1M Na0H using phenolphthalyne as indicator until a pink end point is reached. Tannin content was then calculated in % ($C_1V_1 = C_2v_2$) molarity.

Calculations

Data

C_1 = conc. of Tannic Acid

C_2 = conc. Of Base

V_1 = Volume of Tannic acid

V_2= Volume of Base

Therefore $C_1 = C_2V_2/V_1$

$$\%\ \text{Tannic acid content} = \frac{\text{C1 x 100}}{\text{Weight of sample analyzed}}$$

2.3.8 Oxalate determination by Titration method

This determination involves three major steps digestion, oxalate precipitation and permanganate titration

Digestion: 2g of sample is suspended in 190ml of distilled water in a 250ml volumetric flask. 10ml of 6m HCl is added and the suspension digested at 100^0c for 1 hour. Cool, and then make up to 250ml mark before filtration.

Oxalate precipitation

Duplicate portions of 125ml of the filtrate are measured into beakers and four drop of methyl red indicator added. This is followed by the addition of NH_4OH solution (dropwise) until the test solution changes from salmon pink colour to a faint yellow colour (pH4-4.5). Each portion is then heated to 90^0c, cooled and filtered to remove precipitate containing ferrous ion. The filtrate is again heated to 90^0c and 10ml of 5% $CaCl_2$ solution is added while being stirred constantly. After heating, it is cooled and left overnight at 25^0c. The solution is then centrifuge at 2500rpm for 5minutes. The supernatant is decanted and the precipitate completely dissolved in 10ml of 20% (v/v) H_2S0_4 solution.

Permanganate titration

At this point, the total filtration resulting from digestion of 2g of flour is made up to 300ml. aliquots of 125ml of the filtrate is heated until near boiling and then titrated against 0.05M standardized $KMNO_4$ solution to a faint pink colour which persists for 30s. The calcium oxalate content is calculated using the formula

$T \times (Vme)(Df) \times 10^5 (mg/100g)/ (ME) \times (Mf)$

Where T is the titre of $KMn0_4$(ml), Vme is the volume-mass equivalent (i.e. 1ml of 0.05m $KMn0_4$ solution is equivalent to 0.00225g anhydrous oxalic acid). Df is the dilution factor Vt/A (2.4 where Vt is the total volume of titrate (300ml) and A is the aliquot used (125ml), ME is the molar equivalent of

$KMn0_4$ in oxalate ($KMn0_4$ redox reaction) and Mf is the mass of sample used (Harbone, 1993)

2.3.9 Determination of anthocyanin in the water of life using the gravimetric method of Harborne, 1973

Principle: Acid hydrolysed sample when filtered reacts with ethylacetate to enable extraction of anthocyanin. Upon addition of amyl alcohol, anthocyanin was extracted and after drying, the percent composition was determined in relation to weight of original sample gravimetrically.

Procedure: Five gram (5.0g) of the powdered sample (water of life) was boiled in 100ml of 2MHCl for 30minutes. The hydrolysate was filtered using whatman filter paper. The filterate was transferred into separation funnel and equal volume of ethylacetate added, mixed and allowed to separate into two layers. The ethylacetate layer was recovered while the aqueous layer was discarded. The extract was dried over a steam bath. The dry extract was then treated with 50ml of conc. amylalcohol to extract the anthocyanin. After filtration, the alcohol extract was dried. The weight of anthocyanin was determined and expressed as percentage of original sample.

$$\text{Anthocynanin g(\%)} = \frac{\text{weight of Anthocyanin}}{\text{Wt of original sample}} x\ 100$$

2.3.10 Determination of steroid content

A gram (1.0g) of the powdered sample was weighed and mixed in 100ml of distilled water in a conical flask. The mixture was filtered and the filtrate eluted with 0.1N ammonium hydroxide solution. 2ml of the eluent was put in a test tube and mixed with 2ml of chloroform. 3ml of ice cold acetic anhydride was added to the mixture in the flask. 2 drops of (200mg/dl) standard sterol solution was prepared and treated as described for test as blank. The absorbance of standard and test was measured, zeroing the spectrophotometer with blank at 420nm.

Calculation (mg/100ml)

$$= \frac{\text{Absorbance of test x Conc. of std}}{\text{Absorbance of std.}}$$

2.3.11 Phenol Determination

The quantity of phenol is determined using the spectrophotometer method. The plant sample is boiled with 50ml of $(CH_3CH_2)_20$ for 15min. 5ml of the boiled sample is then pipette into 50ml flask, and 10ml of distilled water is added. After the addition of distilled water, 2ml of NH_4OH solution and 5ml of concentrated $CH_3(CH_2)_3CH_2OH$is added to the mixture. The samples is made up to the mark and left for 30min to react for colour development and measured at 505nm wavelength using spectrophotometer.

2.4 Data Analysis

Results were expressed as mean ± standard deviation of triplicate determinations. Data were analyzed using descriptive statistics.

3. Results

3.1 Proximate Composition

Chromolaena odorata leaves and *Zingiber officinale* (ginger) rhizomes demonstrated notable differences in their nutritional profiles (Table 1). Moisture was higher in ginger (15.96%) than in *C. odorata* (11.93%). Ash, fat, fiber, and protein were higher in *C. odorata* (14.39%, 10.75%, 8.52%, and 10.50%, respectively) than in ginger (5.42%, 3.48%, 1.30%, and 9.45%, respectively). Carbohydrate content was dominant in ginger (64.39%) compared to *C. odorata* (43.93%).

Table 1: Proximate composition of *Chromolaena odorata* leaves and *Zingiber officinale* rhizomes

Parameter	*C. odorata (%)*	*Z. officinale (%)*
Moisture	11.93	15.96
Ash	14.39	5.42
Fat	10.75	3.48
Fibre	8.52	1.30
Protein	10.50	9.45
Carbohydrate	43.93	64.39

3.2 Phytochemical Composition

Phytochemical analysis revealed high concentrations of alkaloids (16.82%) and saponins (19.27%) in *C. odorata*, while ginger had higher levels of steroids (12.69%) and phenols (5.04%). Both plants contained flavonoids, tannins, oxalates, anthocyanins, cardiac glycosides, phytates and cyanogenic glycosides.

Table 2: Phytochemical composition of *Chromolaena odorata* leaves and *Zingiber officinale* rhizomes (mg/100 g)

Phytochemicals	*C. odorata*	*Z. officinale*
Flavonoids	3.63	6.51
Alkaloids	16.82	4.12
Saponins	19.27	7.45
Cardiac glycosides	2.69	1.78
Phytates	0.70	1.05
Cyanogenic glycosides	0.32	3.19
Tannins	1.06	4.29
Oxalates	1.06	0.27
Anthocyanins	2.79	4.28
Steroids	1.65	12.69
Phenols	0.52	5.04

4. Discussion

4.1 Nutritional Implications

The relatively high moisture content in ginger suggests a shorter shelf life, making it prone to microbial spoilage compared to *C. odorata* (Shirin & Prakash, 2010). In contrast, the high ash content of *C. odorata* indicates significant mineral availability, corroborating earlier reports of its mineral richness (Okoli *et al*., 2010).

The crude fat (10.75%) and fiber (8.52%) in *C. odorata* suggest that the plant could promote satiety, lipid metabolism, and gut health, as fiber aids bowel movement and fat provides essential fatty acids (Akinmoladun *et al*., 2016). Ginger, while lower in fat and fiber, remains a strong carbohydrate source (64.39%), making it an energy-rich spice in human diets (Prakash *et al*., 2011).

Both plants provide moderate protein (9–11%), with *C. odorata* slightly higher. Similar values were reported by Ndukwe *et al.* (2019), emphasizing its potential as a supplementary protein source in resource-limited communities.

4.2 Phytochemical and Bioactive Insights

Flavonoids were more abundant in ginger (6.51 mg/100 g), consistent with its known antioxidant and anti-inflammatory activities (Ali *et al*., 2008). Ginger's flavonoid-rich composition is linked to compounds such as gingerols and shogaols, which modulate oxidative stress and inflammatory pathways (Semwal *et al*., 2015).

In contrast, *C. odorata* contained higher levels of alkaloids and saponins. Alkaloids are bioactive agents with analgesic and antimicrobial functions (Edeoga *et al*., 2005), while saponins are associated with cholesterol-lowering, immune-enhancing, and anticancer activities (Obadoni & Ochuko, 2001). This explains the ethnomedicinal use of *C. odorata* in ulcer management and wound healing (Phan *et al*., 2001).

Steroid and phenol contents were markedly higher in ginger. Steroids often exhibit anti-inflammatory activities, while phenols act as potent antioxidants that protect gastric mucosa and modulate enzymatic activity (Shirin & Prakash, 2010). These findings support ginger's use in gastrointestinal disorders.

Both plants contained low concentrations of anti-nutritional factors such as phytates, cyanogenic glycosides, and oxalates. The levels observed fall below toxic thresholds, making them safe for dietary and medicinal use (Olayemi *et al*., 2016).

4.3 Synergistic Therapeutic Value

The nutritional and phytochemical profiles suggest that combining *C. odorata* and ginger could produce synergistic therapeutic effects. *C. odorata* provides proteins, fiber, alkaloids, and saponins that support mucosal protection and healing, while ginger offers carbohydrates, flavonoids, phenols, and steroids with strong antioxidant and anti-inflammatory actions. Such synergy is crucial for gastrointestinal health and ulcer management (Akinmoladun *et al*., 2016; Semwal *et al*., 2015).

4.4 Comparison with Literature

The results align with previous reports. Okoli *et al*. (2010) noted the rich phytochemical composition of *C. odorata*, while Akinmoladun *et al*. (2016) confirmed its proximate values, including high ash, fat, and fiber. For ginger, carbohydrate dominance (65–71%) and the presence of flavonoids, tannins, and phenols have been consistently documented (Ali *et al*., 2008; Shirin & Prakash, 2010). Differences in exact values across studies may result from variations in environmental factors, harvesting methods, and extraction protocols. Nonetheless, the trends are consistent, underscoring the reliability of the present study.

5. Conclusion

Both *C. odorata* and ginger are rich in nutrients and bioactive phytochemicals, supporting their ethnomedicinal use in ulcer management and gastrointestinal health. Their complementary profiles—*C. odorata* being richer in saponins, alkaloids, and minerals, and ginger excelling in flavonoids, phenols, and carbohydrates—justify their combined application in herbal therapy. Further pharmacological and clinical studies are recommended to validate their therapeutic efficacy.

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