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# Qualitative phytochemical screening of aqueous and ethanol extracts of selected Ghanaian spice

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## ABSTRACT

Spices are recognized not only for their culinary value but also for their rich content of bioactive compounds with potential health benefits. This study aimed to qualitatively evaluate the phytochemical constituents of aqueous and ethanol extracts of five widely used Ghanaian spices: black pepper (*Piper nigrum*), grains of paradise (*Aframomum melegueta*), cloves (*Syzygium aromaticum*), West African pepper (*Xylopia aethiopica*), and habanero pepper (*Capsicum chinense*). Plant materials were collected from local markets, processed, and subjected to solvent extraction using water and ethanol. Standard qualitative assays were employed to detect major secondary metabolites, including alkaloids, flavonoids, saponins, phenolics, and phytosterols. Results revealed that aqueous extracts generally yielded a broader spectrum of phytochemicals than ethanol extracts, with flavonoids being the most consistently detected class across species. Cloves exhibited the richest phytochemical profile, containing flavonoids, saponins, phenolics, and phytosterols in both solvent systems. Species-specific variations were noted, such as the presence of alkaloids exclusively in the aqueous extract of black pepper.

**Key words:** Phytochemical screening, Ghanaian spices, Aqueous and ethanol extracts, Natural bioactive compounds

## INTRODUCTION

Spices have long transcended their roles as mere culinary enhancers, emerging as potent sources of bioactive compounds with profound nutritional and therapeutic implications (Dharmian and Ramakrishnan, 2024). These plant-derived substances, such as alkaloids, polyphenols, and terpenoids, contribute not only to the distinctive flavors and aromas of spices but also to their recognized health-promoting properties (Wani *et al.*, 2022). Globally, spices have been integral to traditional medical systems, including Ayurveda, Traditional Chinese Medicine, and Unani, where they are utilized for their antimicrobial, digestive, and anti-inflammatory effects (Khatri *et al.*, 2023). In the African context, particularly in Ghana, spices play a central role in ethnomedicine and local dietary practices. Communities widely rely on them for managing common ailments such as coughs, gastrointestinal disorders, and infections, reflecting both cultural heritage and practical health benefits (Asante *et al.*, 2022). This dual role underscores their significance as functional ingredients with implications for both nutrition and pharmacology.

Phytochemicals are naturally occurring secondary metabolites produced by plants that play vital roles in their defence mechanisms against pathogens, pests, and environmental stressors (Al-Khayri *et al.*, 2023). Unlike primary metabolites such as carbohydrates, proteins, and lipids, phytochemicals are not essential for plant growth but are crucial in conferring health-promoting properties when consumed by humans (Kour *et al.*, 2022). These compounds are broadly classified into several major groups, including alkaloids, flavonoids, tannins, saponins, phenols, terpenoids, and glycosides. The biological relevance of these compounds explains their wide application in traditional medicine and modern pharmacology (Naji *et al.*, 2024). Numerous studies have demonstrated that phytochemicals contribute to antimicrobial defence, antioxidant protection, anti-inflammatory regulation, and even anticancer properties (Khatri *et al.*, 2023).

Qualitative identification of phytochemicals is therefore an essential first step in phytochemical research. This approach is particularly valuable in ethnopharmacology, where confirming traditional uses of spices and herbs requires a scientific understanding of their chemical constituents (Khatri *et al.*, 2023). Hence, qualitative phytochemical screening provides both validation of traditional medicinal practices and direction for modern pharmacological investigations. Therefore, this study aimed to qualitatively determine the phytochemical constituents of aqueous and ethanol extracts of black pepper, grains of paradise, cloves, West African pepper, and habanero pepper.

## MATERIALS AND METHODS

This study was conducted at the Spanish Laboratory of the University for Development Studies, Nyankpala campus, located in the Northern Region of Ghana. Five spices were selected for phytochemical analysis: black pepper (*Piper nigrum*), West African pepper (*Piper guineense*), grains of paradise (*Aframomum melegueta*), cloves (*Syzygium aromaticum*), and habanero pepper (*Capsicum chinense*) (Fig. 1). Dried fruits of black pepper and West African pepper, dried flowers of cloves, and seeds of grains of paradise were purchased from the Aboabo market in Tamale, while fresh fruits of habanero pepper were obtained from the same source. All plant materials were collected in sterile, labelled paper bags and transported to the laboratory.

The plant samples were cleaned and processed prior to extraction. Dried fruits of black pepper, West African pepper, and clove flowers were sorted and sieved, while the shells of grains of paradise seeds were removed. Fresh habanero peppers were cut into 1 cm slices to facilitate drying. All materials were air-dried for 10 days at room temperature under shade. The dried samples were pulverised in a laboratory blender for 5 minutes and passed through a 0.4 mm sieve to obtain fine powders, which were stored in airtight containers until use.

Two different solvents were employed for extraction. For ethanol extracts, 10 g of powdered material was soaked in 300 ml of ethanol and agitated on a shaker for 24 hours. The mixtures were filtered through Whatman No. 1 filter paper, and the filtrates were concentrated to dryness with a rotary evaporator. The dried residues were reconstituted into stock solutions of 1 mg/ml.


West African pepper


Black pepper Cloves

Grains of paradise

**Fig. 1.** Plant materials

For aqueous extracts, 200 g of powdered plant material was steeped in 1 L of sterile distilled water for 24 hours at room temperature with occasional stirring, after which the mixture was filtered through a double-layer cotton cloth, and the filtrates were collected as aqueous extracts (100% stock solution).

Qualitative phytochemical screening was carried out using standard protocols to identify the presence of major secondary metabolites. Alkaloids were detected using Mayer's reagent, where the appearance of a cream precipitate indicated a positive result (Trease, 2002). Saponins were tested by the frothing method, with persistent froth upon warming signifying presence (Adegoke *et al.*, 2011). Phenols were detected using the ferric chloride test, which produced a blue-green colour. Terpenoids were identified through the chloroform–sulphuric acid test, where a reddish-brown colour confirmed their presence (Wadood *et al.*, 2013). Flavonoids were determined by adding magnesium ribbon and concentrated hydrochloric acid to the extracts, with a crimson-red colour indicating a positive result (Kumar *et al.*, 2007). Observations were recorded based on the characteristic colour changes or precipitate formation in each test.

## RESULTS

Qualitative phytochemical screening of the aqueous and ethanol extracts of black pepper, cloves, grains of paradise, West African pepper, and habanero pepper revealed the presence of five classes of secondary metabolites: alkaloids, flavonoids, saponins, phenolics, and phytosterols (triterpenes) (Table 1). Alkaloids were detected only in the aqueous extract of black pepper.

Flavonoids were widely distributed, occurring in the aqueous extracts of all five spices and in the ethanol extracts of cloves, West African pepper, and habanero pepper. Saponins were present in the aqueous extracts of cloves and grains of paradise, while phenolics were restricted to both aqueous and ethanol extracts of cloves. Phytosterols were identified in the aqueous extracts of cloves and grains of paradise and in the ethanol extracts of cloves, grains of paradise, and habanero pepper.

**Table 1.** Phytochemical constituents of aqueous and ethanol extracts of the plant extracts

| Phytochemical constituent | Plant extracts | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Black pepper | | Cloves | | Grains of paradise | | West African pepper | | Habanero | |
| | Aqueous | Ethanol | Aqueous | Ethanol | Aqueous | Ethanol | Aqueous | Ethanol | Aqueous | Ethanol |
| Alkaloids | + | - | - | - | - | - | - | - | - | - |
| Flavonoids | + | - | + | + | + | - | + | + | + | + |
| Saponins | - | - | + | - | + | - | - | - | - | - |
| Phenolics | - | - | + | + | - | - | - | - | - | - |
| Phytosterols (Triterpenes) | - | - | + | + | + | + | - | - | - | + |

Key: + = present; - = absent

Among the studied spices, cloves demonstrated the richest phytochemical profile. The aqueous extract contained flavonoids, saponins, phenolics, and phytosterols, while the ethanol extract contained flavonoids, phenolics, and phytosterols.

This study shows aqueous extracts produced a broader range of phytochemicals than ethanol extracts, although phytosterols were more frequently detected in ethanol fractions. This pattern likely reflects differences in solvent polarity: water, being highly polar, facilitates the extraction of polar compounds such as flavonoids, phenolics, and saponins, whereas ethanol, with lower polarity, is more effective for extracting moderately polar to non-polar compounds, including sterols and terpenoids.

## DISCUSSION

The present study provides evidence that Ghanaian culinary spices are rich sources of diverse secondary metabolites, although differences were observed across species and solvent types. In general, aqueous extracts yielded a broader phytochemical spectrum than ethanol extracts, except for phytosterols, which appeared more frequently in ethanol fractions. Such solvent-dependent variation has also been emphasized in other phytochemical studies, where polarity was shown to influence the recovery of saponins and phenolics.

Among the five spices tested, cloves demonstrated the most complex phytochemical profile, containing flavonoids, saponins, phenolics, and phytosterols in aqueous extracts and flavonoids, phenolics, and phytosterols in ethanol extracts. This pattern is consistent with earlier characterizations of clove extracts that reported multiple metabolite classes, including terpenoids and alkaloids (Kumar *et al.*, 2015). The dominance of flavonoids across nearly all extracts and appearing in both aqueous and ethanol fractions of several species suggests that this class of compounds is widely distributed in these spices. Previous analyses of black pepper (Saranraj *et al.*, 2014) and grains of paradise similarly highlighted flavonoids as major constituents, reinforcing their ubiquity.

Species-specific differences were also evident. Black pepper contained alkaloids uniquely in its aqueous fraction, while grains of paradise produced a combination of flavonoids, saponins, and phytosterols. West African pepper yielded primarily flavonoids, consistent with reports of polyphenolic abundance in this species (Ebana *et al.*, 2016). Habanero pepper exhibited flavonoids and phytosterols, aligning with studies identifying carotenoids and capsaicinoids as additional phytochemicals of importance (Federica *et al.*, 2009). These patterns highlight both shared phytochemical motifs among the spices and unique chemical signatures that may underlie their distinct ethnobotanical uses.

The widespread presence of flavonoids, phenolics, saponins, and phytosterols has important functional implications. These classes of compounds are well recognized for their antimicrobial and antioxidant properties, often acting synergistically to protect plants against microbial invasion. Mechanistically, flavonoids and phenolics exert antimicrobial effects through radical scavenging, metal chelation, and enzyme inhibition (Chaube and Pundhir, 2009). Saponins, by contrast, disrupt microbial membranes via their surfactant properties, whereas phytosterols and terpenoids interfere with cell signaling and membrane stability, contributing to antifungal and anti-inflammatory activity. The detection of these metabolites in spices traditionally used for food preservation and medicine strengthens the rationale for their evaluation as potential botanical fungicides.

Taken together, the phytochemical diversity observed in cloves, black pepper, grains of paradise, West African pepper, and habanero pepper underscore the dual nutritional and pharmacological relevance of these species. Their rich metabolite profiles not only validate long-standing culinary and medicinal applications but also point toward novel opportunities for natural antimicrobial product development.

## CONCLUSION

This study demonstrated that Ghanaian spices, particularly cloves, are rich in diverse phytochemicals with potential antimicrobial applications.

Flavonoids were consistently detected across all species, while cloves exhibited the most comprehensive profile, containing flavonoids, saponins, phenolics, and phytosterols. Such findings support their traditional uses in food preservation and medicine, and point to their possible role as natural alternatives to synthetic fungicides. However, the results were limited to qualitative screening, and no quantitative data on concentration levels were obtained. This constrains direct comparisons between species and limits predictions of potency under practical conditions. Furthermore, phytochemical content can vary significantly depending on environmental factors, harvest time, and extraction methods, raising challenges for reproducibility and large-scale application.

## RECOMMENDATION(S)

Future research should concentrate on quantifying the phytochemicals, evaluating their biological activity (such as antifungal efficacy), and refining extraction techniques in light of the study's qualitative findings. The safety and usefulness of these spice extracts as natural substitutes for synthetic preservatives, fungicides, or medications should also be examined in future studies.

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