Specialty Journal of Pharmacognosy, Phytochemistry, and Biotechnology
ISSN: 3062-441X
2024, Volume 4, Page No: 49-58

Available online at: www.galaxypub.co/page/journals

Galaxy Publication

Galaxy Publication

Exploring the Anti-Inflammatory Potential of *Sericanthe chevalieri* and *Ceiba pentandra* as Natural Antitussives for Children

Cheickna Cissé[1,2]*, Mamadou A. Konaré[1], Mariam Samaké[1], Issiaka Togola[1]

[1]Laboratory of Food Biochemistry and Natural Substances (LBASNa), Faculty of Sciences and Techniques (FST), University of Science, Techniques and Technologies of Bamako (USTTB), BP: E3206, Bamako, Mali.
[2]African Center of Excellence in Bioinformatics of Bamako (ACE-B), University of Sciences, Techniques and Technologies of Bamako (USTTB), BP: E3206, Bamako, Mali.

***E-mail** ✉ cheickna2@yahoo.fr

Received: 06 August 2024; **Revised:** 27 November 2024; **Accepted:** 29 November 2024

ABSTRACT

This research aimed to document the medicinal plants traditionally used for childhood cough treatment and to analyze the phytochemical composition of the two most frequently utilized species (*Ceiba pentandra* and *Sericanthe chevalieri*). An ethnobotanical survey was conducted in the Bamako markets, interviewing traditional herbal vendors. Phytochemical analysis was performed using standard colorimetric reactions and precipitation tube tests. Flavonoid content was determined with aluminum trichloride, while total polyphenols were quantified using the Folin-Ciocalteu method. The anti-inflammatory activity of the plant extracts was assessed using the anti-protein denaturation assay. Among the 56 respondents, 17 plant species from 14 botanical families were identified for their antitussive properties. *S. chevalieri* and *C. pentandra* were the most recommended plants. Phytochemical screening confirmed the presence of alkaloids, terpenes, coumarins, tannins, saponins, and flavonoids in both species. The hydroethanolic and aqueous macerations yielded the highest concentrations of flavonoid and phenolic compounds. The hydroethanolic extracts showed the highest anti-inflammatory potential, as measured by the anti-protein denaturation method, with IC50 values of 263.48 ± 20.80 µg/mL for *S. chevalieri* and 420.30 ± 19.80 µg/mL for *C. pentandra*. These results indicate that the extracts of *S. chevalieri* and *C. pentandra* are abundant in bioactive compounds with strong anti-inflammatory effects, supporting their traditional use in the treatment of cough.

Keywords: *Ceiba pentandra*, Traditional medicine, *Sericanthe chevalieri*, Phytochemical composition, Anti-inflammatory effect, Pediatric cough treatment

How to Cite This Article: Cissé Ch, Konaré MA, Samaké M, Togola I. Exploring the Anti-Inflammatory Potential of *Sericanthe chevalieri* and *Ceiba pentandra* as Natural Antitussives for Children. Spec J Pharmacogn Phytochem Biotechnol. 2024;4:49-58. https://doi.org/10.51847/0OVczhRtw1

Introduction

Cough is an important physiological reflex that assists in clearing the respiratory airways, helping the body to expel irritants or blockages [1-3]. It is often the primary symptom of various respiratory infections and non-infectious conditions, especially in children under five. Although cough is commonly linked with cold symptoms, such as nasal congestion, it can also be triggered by conditions like gastroesophageal reflux disease (GERD), bronchial inflammation (e.g., asthma or allergies), and environmental irritants such as cigarette smoke. In 2021, cough and cold symptoms were responsible for 60% of pediatric consultations in Mali [4].

Current cough treatments typically involve expectorants like guaifenesin, erdosteine, and hypertonic saline solutions, as well as mucolytics such as mannitol, which reduce the thickness of mucus [1, 5, 6]. However, concerns about the safety of over-the-counter cough syrups, particularly after the tragic deaths of 66 children in Gambia in 2022 linked to such medications, have raised awareness about the need for safer alternatives [7]. In response, medicinal plants are emerging as a promising and potentially safer treatment option [8-12].

Plants produce a wide range of bioactive compounds due to their intense metabolic processes, and many of these compounds have been recognized for their therapeutic properties, including expectorant and mucolytic effects [13-18]. Traditional plant-based remedies have been used for centuries across various cultures, often with fewer side effects compared to synthetic medications. These natural treatments are also more accessible and cost-effective, making them an appealing option for communities in developing countries [13, 18-23].

In addition to alleviating symptoms, medicinal plants may also target the underlying causes of respiratory conditions, thanks to their diverse range of active compounds [24]. This study aims to document the plants commonly used in Bamako, Mali, for treating children's coughs. We also performed biological investigations on the plants most frequently recommended by traditional healers.

Materials and Methods

To begin this research, an ethnobotanical survey was conducted to gather data on the plant species used for treating cough in children. The objective was to identify the most frequently mentioned plants, which were then selected for further laboratory analysis. This was carried out at the Laboratory of Food Biochemistry and Natural Substances (LBASNa) at the University of Sciences, Techniques, and Technologies of Bamako (USTTB).

Survey area

The ethnobotanical survey took place across various districts of Bamako, including Lafiabougou, Hamdallaye ACI, Djikoroni ACI, and Kalaban Coura ACI. **Figure 1** illustrates the geographic locations of these areas.

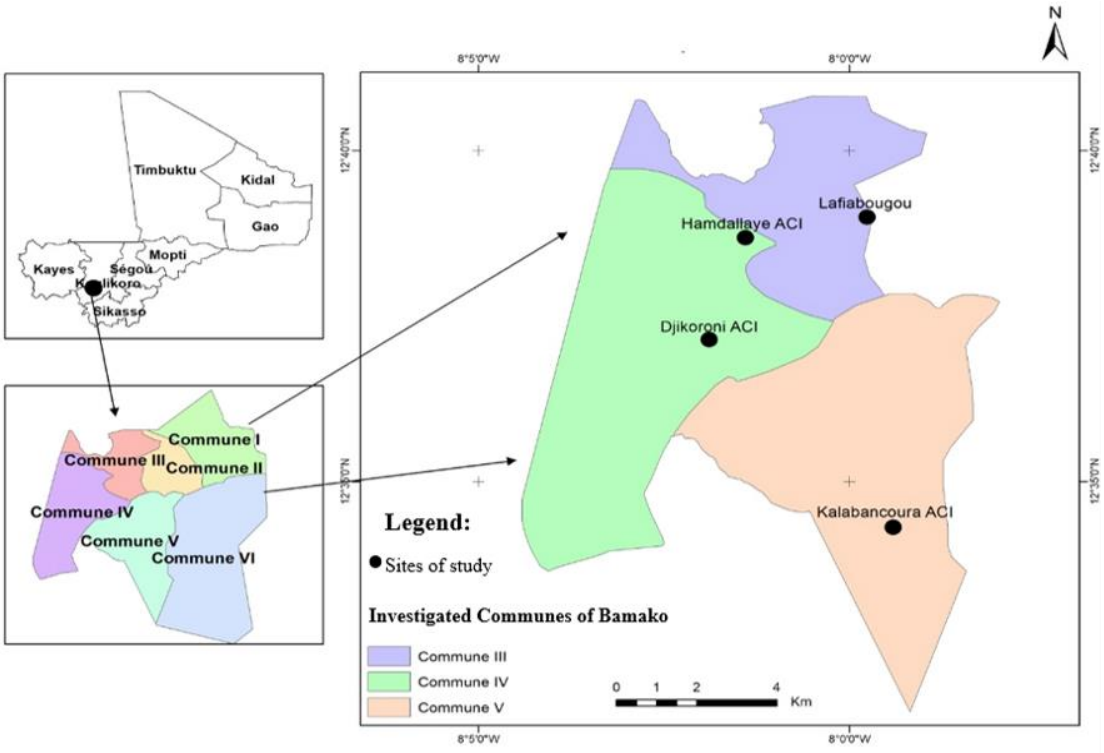

Figure 1. Survey area map showing four neighborhoods of Bamako, Mali.

Plant materials

The plant samples used in this study were obtained from local markets in Bamako. These included the bark of *Ceiba pentandra* (L.) Gaertn. and the leafy branches of *Sericanthe chevalieri* (K. Krause) Robbr. The identification of these species was carried out at the Laboratory of Botany and Ecotoxicology within the Faculty of Sciences and Techniques (FST), USTTB. After collection, the plant materials were washed thoroughly, air-dried, ground into fine powder, and stored away from light and humidity to maintain their integrity.

Methodological approach

Ethnobotanical survey

The survey employed a structured questionnaire to document the use of plants in treating coughs among children, with data collected from interviews conducted with market vendors, traditional healers, and residents of the study areas. The survey was conducted over six months (February to July 2022).

Participants

The study involved a range of participants, including herbalists, medical professionals, market vendors, and academic researchers. Participants were selected at random, and informed consent was obtained in either verbal or written form.

Preparation of extracts

For the extraction process, 50 g of dried plant material was macerated in 1500 mL of distilled water or 70% ethanol at room temperature for 24 hours, followed by vacuum filtration. Additionally, a decoction was prepared by boiling 50 g of plant powder in 1500 mL of distilled water for 15 minutes, after which it was filtered under vacuum.

Phytochemical screening

To determine the presence of bioactive compounds, qualitative reactions were carried out on the plant extracts to identify polyphenols (such as tannins, flavonoids, saponins, and coumarins), alkaloids, and terpenes. These tests followed the procedures outlined by Konaré *et al*. [14, 25]. Results were recorded as either positive (+) or negative (-).

Quantification of phenolic compounds

The Folin-Ciocalteu method was used to quantify the total phenolic content, in line with the protocol established by Konaré *et al*. [14]. A 500 µL aliquot of the Folin-Ciocalteu reagent (diluted to 10%) was mixed with 100 µL of the plant extract and 400 µL of sodium carbonate (Na2CO3) solution (75 mg/mL). After incubation for 2 hours at room temperature in the dark, absorbance was measured at 765 nm. A calibration curve using gallic acid at concentrations between 0–100 µg/mL was constructed, and the phenolic content was calculated based on the calibration curve. The results are expressed as milligrams of gallic acid equivalent per gram of extract (mg GAE/g). Each measurement was repeated three times for accuracy.

Flavonoid content analysis

To quantify the total flavonoids, we employed the aluminum chloride method as outlined by Konaré *et al*. [14]. The process involved mixing 200 µL of the extract with 800 µL of water and adding 50 µL of a 5% sodium nitrite solution. After a 5-minute incubation at room temperature (25–30 °C), 50 µL of 10% AlCl3 was added to the mixture. This was followed by a further 6 minutes of incubation, after which 400 µL of 1 M sodium acetate and 1 mL of water were added. The absorbance at 510 nm was measured using a Thermo Scientific Biomate 3S spectrophotometer. For calibration, quercetin at concentrations between 20 and 120 µg/mL was used. Flavonoid levels were calculated based on the calibration curve, with results reported in terms of milligrams of quercetin equivalent per gram of extract (mg QE/g).

Anti-inflammatory evaluation

The anti-inflammatory activity was assessed using the method of protein denaturation as described by Gambhire *et al*. [26], with modifications by Koné *et al*. [27]. To prepare the reaction mixture, 1 mL of egg white solution was mixed with 3 mL of phosphate-buffered saline (PBS, pH = 6.4), along with 1 mL of the plant extract at various concentrations (62.5, 125, 250, 500, and 1000 µg/mL). A control was prepared using distilled water. After an incubation period of 15 minutes at 37 °C, the mixtures were heated at 70 °C for 5 minutes. The absorbance at 660 nm was measured once the mixtures cooled. Sodium diclofenac was tested as a reference at concentrations between 62.5 and 1000 µg/mL. The inhibition of protein denaturation was calculated using the following formula:

$$\% \text{ Inhibition } = (1 - \frac{\text{Absorbances of samples}}{\text{Absorbances of control}}) \times 100 \quad (1)$$

Statistical processing

Data from the ethnobotanical survey were processed using SPSS software. For the statistical evaluation of quantitative data, such as total phenolic and flavonoid content, as well as anti-inflammatory activity, Minitab v18.1 was used. Statistical comparisons of the means were made using analysis of variance (ANOVA), and Fisher's test was applied with a significance level of P = 0.05.

Results and Discussion

Ethnobotanical survey

A total of 56 respondents took part in the survey with ages ranging from 25 to 75 years. The majority belonged to the 25–35 years age group. The participants primarily consisted of traditional healers, with additional contributions from herbalists, researchers, physicians, and vendors of medicinal plants. Based on their responses, the oral route was the most commonly used method for administering treatments for childhood cough, while decoction was the most frequently mentioned extraction technique, accounting for 86% of all reported uses. The medicinal plant species identified during the survey, along with their citation frequencies, are detailed in **Table 1**.

Table 1. List and fidelity level of recommended plants

Scientific names	Botanical families	Organs used	Fidelity level (FL) (%)
Grossopteryx febrifuga	Rubiaceae	Leaves + Seeds	75.00
Anacardium occidentale	Anacardiaceae	Branches	23.21
Ceiba pentandra	**Bombacaceae**	**Bark**	**19.64**
Sericanthe chevalieri	**Rubiaceae**	**Leaves**	**19.64**
Pteleopsis suberosa	Combretaceae	Branches	17.86
Acacia albida	Fabacea	Bark	12.50
Mangifera indica	Anacardiaceae	Leaves	5.36
Vitex mandiensis	Lamiaceae	Leaves	3.57
Piliostigma thonningii	Fabaceae	Leaves	1.79
Acacia nilotica	Fabaceae	Leaves + Seeds	1.79
Ximenia amercanalim	Olacaceae	Branches	1.79
Vitellaria paradoxa	Sapotaceae	Leaves	1.79
Saba senegalesis	Apocynaceae	Leaves	1.79
Guiera senegalesis	Guiera	Leaves	1.79
Pterocarpus erinaceus	Fabaceae	Leaves	1.79
Ficus thonningi	Moraceae	Leaves	1.79

Note: The fidelity level or index (FL) is the percentage of informants who cited the use of a given species in the treatment of a pathology.

In total, 17 plant species were documented, with the Rubiaceae family being the most frequently cited, followed by Anacardiaceae. Among the listed species, *S. chevalieri* and *C. pentandra* stood out as the most frequently referenced, both exhibiting a fidelity level of 19.64%. Consequently, these species were chosen for further biochemical and pharmacological investigations.

Phytochemical screening

The phytochemical composition of the extracts obtained through aqueous maceration, hydroethanolic maceration, and decoction for both *S. chevalieri* and *C. pentandra* is summarized in **Table 2**.

Table 2. Phytochemical composition of *S. chevalieri* and *C. pentandra* extracts

	S. chevalieri			***C. pentandra***		
Phytochemical groups	**Aqueous maceration**	**Hydroethanol ic maceration**	**Decoction**	**Aqueous maceration**	**Hydroethanolic ic maceration**	**Decoction**
Alkaloids	+	+	+	+	+	+
Tannins	+	+	+	+	+	+

Flavonoids	+	+	+	+	+	+
Coumarins	+	+	+	+	+	+
Saponines	+	+	-	+	+	-
Terpenoids	+	+	+	+	+	+

(+): presence et (-): absence

The phytochemical analysis confirmed the presence of alkaloids, tannins, flavonoids, coumarins, and terpenoids in the extracts from both plant species. However, saponins were not detected in the decoction extracts of either *S. chevalieri* or *C. pentandra*.

Polyphenol and flavonoid content

The quantified levels of total polyphenols and flavonoids in the plant extracts are displayed in **Table 3**.

Table 3. Polyphenol and total flavonoid contents of *S. chevalieri* and *C. pentandra* extracts

Plants	Extracts	Flavonoids (mg QE/100g)	Polyphenols (mg GAE/g)
S. chevalieri	Aqueous macerate	0.268 ± 0.005^{aB}	0.305 ± 0.005^{cA}
	Hydro-ethanol macerate	0.125 ± 0.005^{cB}	0.648 ± 0.022^{aA}
	Decocted	0.159 ± 0.002^{bB}	0.431 ± 0.014^{bA}
C. pentandra	Aqueous macerate	0.468 ± 0.010^{aA}	0.146 ± 0.019^{cB}
	Hydro-ethanol macerate	0.070 ± 0.002^{cA}	0.544 ± 0.024^{bA}
	Decocted	0.357 ± 0.008^{bA}	0.350 ± 0.025^{bB}

Note: Different lowercase letters indicate significant variations within the same plant species, whereas different uppercase letters denote significant differences across extraction types.

The aqueous maceration extracts contained the highest flavonoid levels, with *S. chevalieri* and *C. pentandra* yielding 0.268 ± 0.005 mg QE/100g and 0.468 ± 0.010 mg QE/100g, respectively. Meanwhile, polyphenol content was highest in the hydroethanolic maceration extracts, where *S. chevalieri* recorded 0.648 ± 0.022 mg GAE/g and *C. pentandra* reached 0.544 ± 0.024 mg GAE/g.

Anti-inflammatory activity

The effectiveness of *S. chevalieri* and *C. pentandra* extracts in inhibiting protein denaturation is depicted in **Figures 2 and 3**.

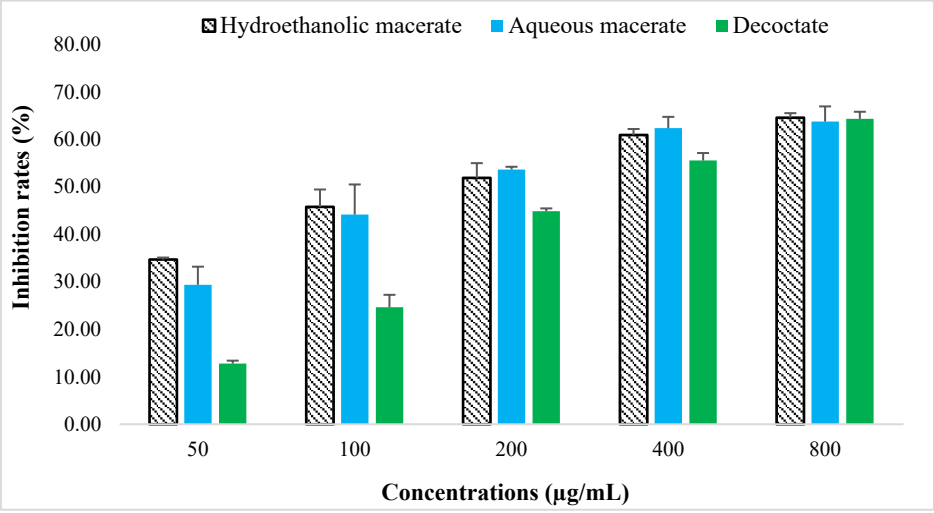

Figure 2. Effects of *S. chevalieri* extracts on protein denaturation

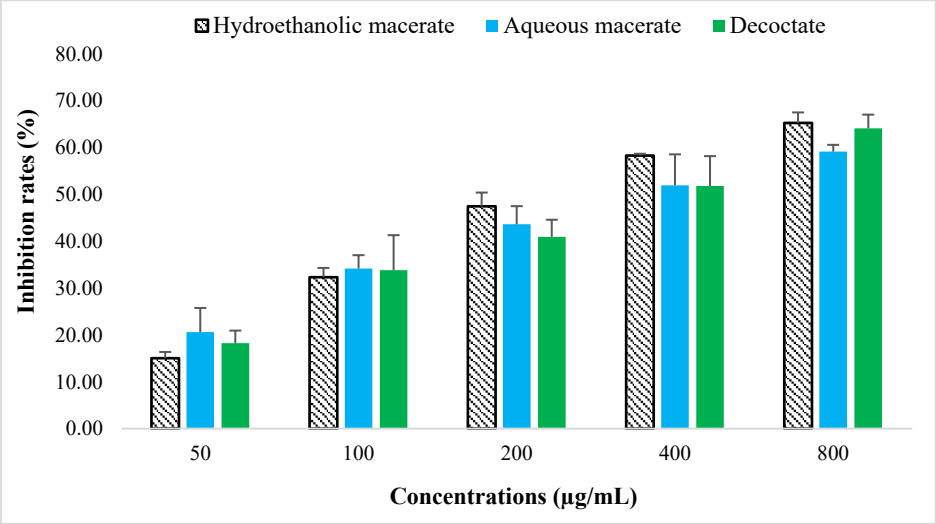

Figure 3. Effects of *C. pentandra* extracts on protein denaturation

As illustrated in **Figures 2 and 3**, extracts derived from *S. chevalieri* and *C. pentandra* exhibited the ability to prevent protein denaturation across a concentration spectrum of 50 to 800 µg/mL.
The IC50 values (concentrations required to inhibit 50% of protein denaturation) for both species are summarized in **Table 4**.

Table 4. IC50 values for protein denaturation inhibition

Extract type	IC50 (µg/mL) – *C. pentandra*	IC50 (µg/mL) – *S. chevalieri*
Aqueous maceration	485.60 ± 0.00a	292.48 ± 13.97c
Hydroethanolic maceration	420.30 ± 19.80b	263.48 ± 20.80b
Decoction	464.00 ± 18.30a	429.12 ± 14.47a
P-value	**0.006 < 0.05**	**0.00004 < 0.05**

Note: Within each plant species, values marked with different letters indicate statistically significant differences.

The hydroethanolic maceration extract of *S. chevalieri* demonstrated the strongest inhibitory activity against protein denaturation, with an IC50 of 263.48 ± 20.80 µg/mL. In contrast, the aqueous maceration extract of *C. pentandra* showed the least inhibitory effect, requiring a concentration of 485.60 ± 0.00 µg/mL to achieve 50% inhibition.

Inhibitory potential of plant extracts
The aqueous and hydroethanolic extracts of *S. chevalieri* displayed the strongest inhibition effects, with IC50 values of 292.48 ± 14 µg/mL and 263.79 ± 20 µg/mL, respectively. Meanwhile, *C. pentandra* extracts did not exhibit notable variations across different extraction techniques, with IC50 values recorded at 485.62 µg/mL (aqueous), 420.26 ± 20 µg/mL (hydroethanolic), and 463.98 ± 14 µg/mL (decoction) **(Table 4)**.

Traditional use of medicinal plants for childhood cough
Cough is a frequent concern in children, leading many parents to seek alternative remedies due to safety concerns associated with conventional medications. Herbal treatments are being increasingly explored as affordable, sustainable, and safer solutions.
This study sought to identify locally used medicinal plants in Bamako for addressing childhood cough. Among those surveyed, 42% were women, while 12% were men. A total of 17 plant species from 14 botanical families were documented, with *C. pentandra* and *S. chevalieri* emerging as the most frequently cited, each achieving a fidelity index (NF) of 19.64%. The Rubiaceae, Anacardiaceae, and Bombacaceae families were the most represented.
The leaves were the most commonly used plant part (72 citations), followed by branches (35 citations) and bark (12 citations). The preference for leaves is likely due to their high concentration of medicinal compounds, which contribute to their therapeutic properties [28-31].

The harvesting of leaves is also encouraged since it poses minimal risk to plant survival, thus promoting biodiversity conservation [32]. The study also found that oral consumption was the dominant mode of administration. Romuald *et al*. [32] suggested that this may be because many of the treated ailments involve internal infections caused by bacteria or fungi.

Further pharmacological research on *C. pentandra* has confirmed that both leaves and bark are traditionally employed in the treatment of cough, fever, and other health conditions [20, 21, 33-38].

Chemical composition of extracts

Phytochemical analysis indicated that saponins were absent in decoctions, but other bioactive compounds such as alkaloids, tannins, flavonoids, coumarins, and terpenoids were identified in different extracts.

These findings contrast with Tala *et al*. [38], who reported the presence of saponins in *C. pentandra* bark. This variation could be attributed to differences in extraction techniques or environmental conditions [39-42].

Polyphenol and flavonoid content

Analysis of the extracts revealed that:

Flavonoid levels were highest in aqueous extracts, measuring 0.268 ± 0.005 mg QE/100 g for *S. chevalieri* and 0.468 ± 0.010 mg QE/100 g for *C. pentandra*.

Polyphenol concentrations peaked in hydroethanolic extracts, with values of 0.648 ± 0.022 mg GAE/g (*S. chevalieri*) and 0.544 ± 0.024 mg GAE/g (*C. pentandra*).

These findings suggest that hydroethanolic maceration is superior for extracting polyphenols, whereas aqueous maceration is more effective for flavonoids. This aligns with existing research indicating that hydroethanolic solutions efficiently extract phenolic compounds, known for their biological activity [25, 31, 43, 44].

The high polyphenol and flavonoid content likely contribute to the antioxidant effects of these plants, supporting their traditional role in treating inflammation-related ailments [17, 21, 45, 46]. Loganayaki *et al*. [36] further confirmed that *C. pentandra* extracts are rich in polyphenols and flavonoids, which correlate with their strong antioxidant properties.

Anti-inflammatory effects and protein denaturation

Inflammation is largely driven by protein denaturation, making it a key factor in assessing anti-inflammatory potential [25, 26, 47].

As shown in **Figure 2**, the aqueous extract of *S. chevalieri* exhibited the strongest anti-inflammatory effect. In contrast, *C. pentandra* extracts displayed comparable anti-denaturation effects across different extraction types **(Figure 3)**. Despite their activity, both plant extracts exhibited lower anti-inflammatory potency compared to diclofenac.

According to **Table 4**, the aqueous and hydroethanolic extracts demonstrated the most notable anti-inflammatory activity, with IC50 values of 292.48 ± 13.97 µg/mL (*S. chevalieri*) and 420.30 ± 19.80 µg/mL (*C. pentandra*). Statistical analysis confirmed significant differences ($P < 0.05$) between the two species.

These values were lower than those reported by Abouelela *et al*. [20], who found that *C. pentandra* extracts exhibited anti-inflammatory effects comparable to ascorbic acid. Differences in outcomes could stem from variations in plant parts used, extraction techniques, or environmental factors in the collection regions [15, 48, 49].

Further chemical analysis of *S. chevalieri* and *C. pentandra* extracts should focus on pinpointing the specific bioactive components driving their effects. Research suggests that flavonoids and tannins play a major role in the anti-inflammatory effects of medicinal plants [13, 21, 50]. A deeper examination of these compounds could provide valuable insights into the mechanisms behind their therapeutic potential.

Conclusion

This study highlighted *S. chevalieri* and *C. pentandra* as the most commonly used medicinal plants for treating cough in Bamako, Mali. The leaves and branches were identified as the primary plant parts utilized, with decoction being the preferred preparation method.

Phytochemical analysis confirmed that *S. chevalieri* leaves and *C. pentandra* bark are rich in secondary metabolites. Quantitative assessments revealed that hydroethanolic extracts of *S. chevalieri* contained notably

high levels of polyphenols and flavonoids, whereas the aqueous extract of *C. pentandra* exhibited a significant flavonoid concentration.

While both plants demonstrated promising anti-inflammatory properties, their effectiveness in traditional medicine can likely be attributed to the presence of these bioactive metabolites. However, further studies are essential to refine the characterization of active compounds and validate their in vivo efficacy. Such research efforts will enhance our understanding of medicinal plants and contribute to developing natural therapies for managing inflammation associated with childhood coughs.

Acknowledgments: None

Conflict of Interest: None

Financial Support: None

Ethics Statement: None

References

1. Canning BJ, Chang AB, Bolser DC, Smith JA, Mazzone SB, McGarvey L. Anatomy and neurophysiology of cough: CHEST guideline and expert panel report. Chest. 2014;146(6):1633-48.
2. Andrani F, Aiello M, Bertorelli G, Crisafulli E, Chetta A. Cough, a vital reflex. Mechanisms, determinants, and measurements. Acta Biomed. 2018;89(4):477.
3. Saadat S, Shakeri F, Boskabady MH. Comparative antitussive effects of medicinplants and their constituents. Altern Ther Health Med. 2018;24(4):36-49.
4. Kané B, Camara M, Dembélé G, Togo S, Traoré M, Diallo K, et al. Epidemiological aspect of community acute pneumopathy of children in the pediatric service of Mali Hospital. Rev Malienne d'infectiologie Microbiol. 2020;10(1):64-70.
5. Yadav S, Mishra AP, Kumar S, Negi A, Asha, Maurya VK. Preparation of phytopharmaceuticals for the management of disorders: The development of nutraceuticals and traditional medicine. Elsevier; 2021. p. 169-84. doi:10.1016/B978-0-12-820284-5.00007-1
6. Ganga NP. The therapeutic applications of cough medicines in respiratory diseases. Int J Pharm Phytopharmacol Res. 2021;11(3):6-10.
7. OMS. Sirop contre la toux et le rhume: l'OMS ouvre une enquête après la mort de 66 enfants en Gambie [Internet]. OMS; 2022 [updated 2022 October 6; cited 2024 september 23].
8. Chaachouay N, Zidane L. Plant-derived natural products: a source for drug discovery and development. Drugs Drug Candidates. 2024;3(1):184-207.
9. Chopra B, Dhingra AK. Natural products: a lead for drug discovery and development. Phytother Res. 2021;35(9):4660-702.
10. Diallo BN, Swart T, Hoppe HC, Bishop ÖT. Potential repurposing of four FDA-approved compounds with antiplasmodial activity identified through proteome scale computational drug discovery and in vitro assay Groningen Machine for chemical simulations. Sci Rep. 2021;11(1413):1-15.
11. Diallo BN, Glenister M, Musyoka TM, Lobb K, Bishop ÖT, Tastan Bishop Ö. SANCDB: an update on South African natural compounds and their readily available analogs. J Cheminform. 2021;13(1):1-14.
12. Simoben CV, Qaseem A, Moumbock AFAA, Telukunta KK, Günther S, Sippl W, et al. Pharmacoinformatic investigation of medicinal plants from East Africa. Mol Inform. 2020;39(11):1-15.
13. Konaré MA, Condurache NN, Togola I, Păcularu-Burada B, Diarra N, Stănciuc N, et al. Valorization of bioactive compounds from two underutilized wild fruits by microencapsulation in order to formulate value-added food products. Plants. 2023;12(2):267.
14. Konaré MA, Diadie Maïga A, Togola I, Diarra N. Antioxidant and antidiabetic potential of extracts from Anacardium occidentale and Sclerocarya birrea. J Biochem Technol. 2024;15(3):15-24.
15. Majolo F, de Oliveira Becker Delwing LK, Marmitt DJ, Bustamante-Filho IC, Goettert MI. Medicinal plants and bioactive natural compounds for cancer treatment: Important advances for drug discovery. Phytochem Lett. 2019;31(5):196-207.

16. Ntie-Kang F, Telukunta KK, Döring K, Simoben CV, A. Moumbock AF, Malange YI, et al. NANPDB: a resource for natural products from Northern African sources. J Nat Prod. 2017;80(7):2067-76.
17. Togola I, Dembélé AA, Tounkara F, Diarra N, Konaré MA, Karembé M, et al. Evaluation of in vitro antioxidant activities of ethanol extracts of Datura innoxia Mill. Leaves and Seeds Harvested in Mali. Ann Res Rev Biol. 2019;33(2):1-8.
18. Togola I, Konaré MA, Diakité M, Diarra N, Tounkara F, Sanogo R, et al. Evaluation de la teneur en alcaloïdes totaux a differents stades de developpement de Datura innoxia Mill., une plante utilisee dans la medecine traditionnelle au Mali. Am J Innov Res Appl Sci. 2019;9(2).
19. Pal M, Das R, Ghosh N, Kundu A, Saha A, Sharma C, et al. Effect of some medicinal plants as antitussive potential- a review. Int J Biol Pharm Allied Sci. 2024;13(5):2073-81.
20. Abouelela ME, Orabi MAA, Abdelhamid RA, Abdelkader MS, Madkor HR, Darwish FMM, et al. Ethyl acetate extract of Ceiba pentandra (L.) Gaertn. Reduces methotrexate-induced renal damage in rats via antioxidant, anti-inflammatory, and antiapoptotic actions. J Tradit Complement Med. 2020;10(5):478-86.
21. Orabi MAA, Abouelela ME, Darwish FMM, Abdelkader MSA, Elsadek BEM, Al Awadh AA, et al. Ceiba pentandra ethyl acetate extract improves doxorubicin antitumor outcomes against chemically induced liver cancer in rat model: a study supported by UHPLC-Q-TOF-MS/MS identification of the bioactive phytomolecules. Front Pharmacol. 2024;15:1337910.
22. Islamoglu MS, Uysal BB, Yavuzer S, Cengiz M. Influence of the use of medicinal plants on the level of medication adherence in the Elderly. Int J Pharm Phytopharmacol Res. 2024;14(1):16-22.
23. Guindo F, Konaré MA, Daou C, Cissé F. Inventory of local practices of use and conservation of baobab products in two regions of Mali. J Food Stud. 2022;11(1):21.
24. Chiribagula B, S BA, E NI, E KM, Ndjolo P, J KB, et al. Criblage phytochimique et activité antimicrobienne de sept fleurs comestibles utilisées en médecine traditionnelle à Lubumbashi (RDC). J Appl Biosci. 2018;2(1).
25. Konaré MA, Cissé C, Togola I, Fomba M. Inhibitory effects of Datura innoxia Mill extracts on two enzymes involved in the control of diabetes and inflammation. Annu Res Rev Biol. 2024;39:11-8.
26. Gambhire M, Juvekar A, Wankhede S. Evaluation of anti-inflammatory activity of methanol extract of Barleria Cristata leaves by in vivo and in vitro methods. Internet J Pharmacol. 2008;7(1):1-4.
27. Koné MO, Togola I, Konaré MA, Diarra N, Sanogo R, Karembé M. In vitro, anti-inflammatory, and anti-cholesterolemic activities of Chrysanthellum americanum (L) vatke harvested in mali. Int J Biochem Res Rev. 2022;31(10):91-9.
28. Begbin EK, Odoh EA, Zougrou EG, Kablan CLA, Kouakou KK. Évaluation des activités hypoglycémiantes et anti-hyperglycémiantes de l'extrait aqueux des feuilles de Cnestis ferruginea vahl ex dc. (Connaraceae) chez la souris saine. Rev Ivoir Sci Technol. 2021;37(2021):186-95.
29. Lebri M, Bahi C, Fofie N, Gnahoue G, Lagou S, Achibat H, et al. Analyse phytochimique et évaluation de la toxicité aiguë par voie orale chez des rats de l'extrait total aqueux des feuilles de Abrus precatorius Linn (Fabaceae). Int J Biol Chem Sci. 2015;9(3):1470-6.
30. Chatterjee A, Singh N, Chanu WK, Singh CB, Nagaraj VA. Phytochemical screening, cytotoxicity assessment, and evaluation of in vitro antiplasmodial and in vivo antimalarial activities of Mentha spicata L. methanolic leaf extract. J Ethnopharmacol. 2022;298:115636. doi:10.1016/j.jep.2022.115636
31. Samake S, Togola I, Diarra N, Samake M, Sanogo R. Etude ethnobotanique et screening phytochimique de plantes ornementales à usage therapeutique du district de bamako, mali. Int J Adv Res. 2020;8(8):251-62.
32. Romuald KS, Blaise KW, Konan YA, Djakalia OU. Plantes utilisées dans le traitement traditionnel de l'infertilité féminine dans le département de Dabakala (Côte d'Ivoire). J Anim Plant Sci. 2019;42(1):7086-99.
33. Elumalai A, Mathangi N, Didala A, Kasarla R, Venkatesh Y. A review on Ceiba pentandra and its medicinal features. Asian J Pharm Technol. 2012;2(3):83-6.
34. Chan EWC, Yeong SW, Wong CW, Soo OYM, Phua ACY, Ng YK. Ceiba pentandra (L.) Gaertn: an overview of its botany, uses, reproductive biology, pharmacological properties, and industrial potentials. J Appl Biol Biotechnol. 2023;11(1):1-7.
35. Silué GNA, Belemlilga MB, Djadji ATL, Traoré KT, Boly GAL, Koala M, et al. Anti-inflammatory and antioxidant activities assessment of an aqueous extract of Ceiba pentandra (L.) Gaertn (Malvaceae). RPS Pharm Pharmacol Rep. 2023;2(4):1-8.

36. Loganayaki N, Siddhuraju P, Manian S. Antioxidant activity and free radical scavenging capacity of phenolic extracts from Helicteres isora L. and Ceiba pentandra L. J Food Sci Technol. 2013;50(4):687-95.
37. Ojurongbe O, Nguetse CN, Fayemiwo SA, Falade CO, Ojurongbe TA, Thomas BN, et al. High prevalence of dihydrofolate reductase gene mutations in Plasmodium falciparum parasites among pregnant women in Nigeria after reported use of sulfadoxine-pyrimethamine. Pathog Glob Health. 2018;112(2):86-92.
38. Tala VRS, Tcheghebe OT, Happi MZY, Ernest T, Munvera AM, Mkounga P, et al. Phytochemical screening and antibacterial potential of the trunk bark of Ochthocosmus africanus. Int J Pharm Phytopharmacol Res. 2023;13(6):1-7.
39. Konaré MA, Keita S, Somda MK, Togola I, Diarra N, Sanogo R. Antibacterial activities of extracts from four wild food fruits. Eur J Nutr Food Saf. 2023;15(1):62-71.
40. Keita S, Wélé M, Cisse C, Diarra N, Kirkman L, Baba-Moussa L. Antibacterial and antiplasmodial activities of tannins extracted from Zizyphus mauritiana in Mali. Int J Biochem Res Rev. 2018;24(2):1-8.
41. Süntar I. Importance of ethnopharmacological studies in drug discovery: role of medicinal plants. Phytochem Rev. 2019;19(5):1199-209.
42. Dubey K, Dubey R, Gupta RA, Gupta AK. Anti-diabetic and antioxidant potential of saponin extract of leaves of Zizyphus mauritiana. J Drug Deliv Ther. 2019;9(2-A):75-7.
43. Dembele F, Samake S, Togola I, Karembe M. Etudes ethnobotanique et phytochimique despeces ornementales utilisees au Mali: Cas de Terminalia catappa (L.) dans le district de Bamako. Int J Appl Res. 2021;7(6):01-7.
44. Togola I, Abdoulaye M, Cisse C, Diarra N. Anti-inflammatory and Anti-cancer activities of leaf extracts from three Datura species found in Mali. J Appl Life Sci Int. 2023;26(6):88-97.
45. John KK, Shcherazade OSF, Georges A, Ernest ZN, Roger KK, Emile BK, et al. Activité Anti-inflammatoire et études phytochimiques de l'extrait aqueux des écorces de Distemonanthus benthamianus Baill. (Caesalpiniaceae: Leguminosae - Caesalpinioideae). Eur Sci J ESJ. 2021;17(7):74-94.
46. Adjdir S, Benariba N, Laoufi H, Djaziri R. Phenolic content and antioxidant activity of Ziziphus jujuba Mill. Fruit extracts. Phytotherapie. 2019;17(2):74-82.
47. Taiwo BJ, Miller AH, Fielding AJ, Sarker SD, van Heerden FR, Fatokun AA. Ceibinin, a new positional isomer of mangiferin from the inflorescence of Ceiba pentandra (Bombacaceae), elicits a similar antioxidant effect but no anti-inflammatory potential compared to mangiferin. Heliyon. 2024;10(1).
48. Gebrehiwot S, Shumbahri M, Eyado A, Yohannes T. Phytochemical screening and in vivo antimalarial activity of two traditionally used medicinal plants of Afar region, Ethiopia, against Plasmodium berghei in Swiss Albino mice. J Parasitol Res. 2019;2019(1):4519298.
49. Togola I, Denou A, Dembélé J, Daou C, Dénou A, Diarra N, et al. Ethnobotanical survey and phytochemical screening of some plants used in the management of erectile dysfunction in Bwatun (Mali). J Nat Prod Plant Resour. 2020;9(01):1-8.
50. Sorokina M, Steinbeck C. Review on natural products databases: where to find data in 2020. J Cheminform. 2020;12(1):1-51.