Research Journal of Pharmacognosy (RJP) 8(4), 2021: 53-62
Received: 8 July 2021
Accepted: 4 Sep 2021
Published online: 8 Sep 2021
DOI: 10.22127/RJP.2021.293888.1731

Original article

An Ethnobotanical Study on Medicinal Plants Used as Antidote for Snakebite and as Snake Repellent in the Ejisu-Juabeng District of Ghana

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Abstract

Background and objectives: Anecdotal evidence shows that plant remedies used by rural folks to repel snakes and those used during snake envenomation are sometimes effective and offer an appreciable survival rate among victims of snake bites. This study focused on documenting plants that repel snakes from homesteads and those administered as interventions during snake bites among indigenes of Ejisu-Juabeng District, Ghana. **Method:** Personal interviews with indigenes was carried out. Information about the plants including scientific names, families, local names, growth habit, the used part, method of preparation and administration were recorded. Herbarium vouchers were used to identifying the plants at species level. The frequency of citation (FC) and relative frequency of citation index (RFC) for each species was determined. **Results:** Twenty-three medicinal plants were documented; 17 plants belonging to 15 genera from 13 families were reported to be used as antidote for snakebite poisoning while ten species belonging to nine genera from nine families were reported as snake repellents. Plants belonging to the family Apocynaceae were the most predominant (12.5%). The anti-venin plants mostly mentioned were herbs (48%) and trees (39%). Leaves (58.8%) and roots (29.4%) were frequently used in antivenin formulations and were mostly applied topically (78.5%) as poultices or orally (21.4%) as infusions/decoctions. For snake repelling plants the strong odour from plants was mostly responsible for the repellent effect. The most commonly named plants were *Nicotiana tobacum* (Relative frequency of citation=0.26), *Allium sativum* (RFC=0.14), *Rauwolfia serpentine* (RFC=0.18) and *Allium cepa* (RFC=0.18). **Conclusion:** This study has revealed the importance of herbal medicine used in the prevention and treatment of snakebites among indigenes of Ejisu-Juabeng District.

Keywords: antivenom; Ejisu-Juabeng; ethnomedicine; Ghana; repellent

Citation: Asante-Kwatia E, Mensah AY, Fobi EA. An ethnobotanical study on medicinal plants used as antidote for snakebite and as snake repellent in the Ejisu-Juabeng District of Ghana. Res J Pharmacogn. 2021; 8(4): 53–62.

Introduction

Envenomation from snakebites is an important neglected global health issue common in Asia and sub-Saharan Africa [1]. Worldwide, snakebites occur in at least 1.8–2.7 million people every year causing about 81,000 deaths annually. In sub-Saharan Africa alone, mortality estimates range from 7,000 to 32,000 per year with West Africa recording an annual mortality of about 5,450 [2]. Snakebite envenoming is an environmental and occupational hazard which often affects farmers, hunters and dwellers of rural communities where access to basic healthcare facilities is usually limited [3]. Though anti-venom immunotherapy is the only specific treatment against snake envenomation, it is sadly reported that only about 10% of victims of snakebites receive appropriate treatment due to the unavailability of anti-serum therapy and high cost where available [4, 5]. Without treatment, many of these victims die or suffer permanent

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life-altering disabilities such as amputations, disfigurements, chronic wounds and abscesses, chronic pain, nerve damage, miscarriages, kidney failures, blindness and partial or complete loss of function of the affected limb [1,2].

In Ghana, the saw-scaled viper, *Echis ocellatus* Stemmler, is the cause of majority of snake envenomation. The rural population, mostly farmers, are those usually exposed to the vipers [6,7]. Envenomation by this species is known to cause systemic coagulopathies and tissue necrosis at the affected limb. Anti-venoms such as Asna Antivenom C (AV-C) (Bharat Serum and Vaccines Ltd, Mumbai, India) and FAV-Afrique polyvalent anti-venom (Avenits Pasteur) are the most frequently used for treatment of snakebites in Ghana [8]. Regrettably, these antivenoms are often unavailable and/or very expensive for victims to purchase [9]. Consequently, victims may have to substitute conventional antivenom therapy with treatment from traditional healers who use topical and ingested herbs, incisions, ligatures and other techniques to prevent death from snakebites [10]. As an alternative way to reduce the number of human-snake encounters, some communities and individuals have also adopted the cultivation of plants that are claimed to have snake-repelling properties [11].

The Ejisu-Juaben District in the Ashanti region of Ghana lies within a semi-deciduous forest zone where flora and fauna are diverse and composed of different species of medicinal, economic and ornamental importance [12]. The proximity of human settlements to forests as well as the occupation of most of the natives (rural farmers), put them at a daily risk of encounter with venomous snakes. Indigenes place an invaluable importance on plant-based remedies which are readily available especially in emergency situations like snakebite [13, 14]. In a recent study by Steinhorst et al., traditional healers in parts of the Ashanti and Northern regions of Ghana described a holistic approach to treating snakebites with therapies ranging from herbal medicines to minor surgical interventions [15].

Though very common in practice, little is documented about specific medicinal plants commonly used by the local people for the treatment of snakebites. In this study, an ethnobotanical survey was undertaken in the Ejisu-Juaben District in the Ashanti region of Ghana to obtain data on plant-based medicines commonly used by indigenes as remedy to snakebite envenomation and as snake repellents in their homesteads and farms.

Materials and Methods

Ethical considerations

Ethical approval for the study was granted by the Committee on Human Research, Publication and Ethics, Kwame Nkrumah University of Science and Technology (CHRPE) in February, 2019. Further approval was obtained from the community heads or chiefs of the studied communities. Before conducting the interview, the objective of the study was clearly explained to the participants and they also gave their voluntary oral prior consent.

Study area

The ethnobotanical study was conducted in the Ashanti Region of Ghana specifically in the Ejisu- Juaben District (Figure 1). The Ejisu-Juaben District is one of the 27 administrative and political districts in the Ashanti Region of Ghana located in the central part of the region (1.15˚N and 1.45˚N and longitude 6.15˚W and 7.00˚W). It has an estimated population of about 150,000 with about 72% residing in rural areas [12].

Data collection

The ethnobotanical survey was carried out between April and June 2019 in eight villages in the district namely Besease, Gyamaase, Ejisu-Abankrom, Onwe, Donyina, Essieninpong, Atia and Bonwire. Data was collected through a survey employing open-ended semi-structured questionnaires designed in English and translated into the local dialect (Ashanti-Twi). Farmers and residents of communities with close proximity to forests were mostly interviewed as these persons are likely to encounter snakes often. Additionally, indigenes who are known by the people as traditional medical practitioners (herbalists) were also interviewed. A total of 80 individuals, 44 males and 36 females, aged between 30 and 60 were interviewed during the survey. Participants were asked about their knowledge of plants used as snake repellent and as immediate treatment in the event of snake bites; the vernacular name of the plant, the plant part used, the modes of preparation and method of administration of the remedies were recorded. Informants were interviewed on the basis of their ability to

identify a particular plant by vernacular names. On-the-spot identification of various plant species was done in the field with the aid of a botanist. The botanical names of the various plants were verified using the International Plant Name Index (IPNI). Voucher specimens were deposited at the Herbarium of the Department of Herbal Medicine, Kwame Nkrumah University of Science and Technology.

Statistical analysis

The frequency of citation (FC) was calculated as follows:

$$FC = \frac{\text{Number of times a species was mentioned}}{\text{Total number of times that all species were mentioned}} \times 100$$

The relative frequency of citation index (RFC) was calculated as follows:

$$RFC = \frac{\text{Number of informants who mentioned the use of the species (FC)}}{\text{Total number of informants participating in the survey}} \times 100$$

The RFC index ranged from "0" when nobody referred to a plant as being useful to "1" when all informants referred to a plant to be useful [16].

Results and Discussion

The use of herbal medicines for primary healthcare is widespread in many Ghanaian communities [17, 18]. Even though there has been some advances in the current health care system of rural-urban areas of Ghana, most indigenes still rely on traditional herbal therapies as remedies to combat a plethora of diseases and conditions including snakebite poisoning [14,15,19]. In this study, the plants that are used in the treatment of snakebites and as snake repellents in the Ejisu-Juabeng District in the Ashanti region of Ghana were recorded in an ethnobotanical survey.

Eighty persons were interviewed in the ethnobotanical study. More than 60% of participants were over 40 years. Those within this age group, mostly farmers, were particularly interviewed based on the assumption that they encounter snakes often due to their occupation and may have more knowledge on plant-based medicines than the younger generation.

Figure 1. Map of Ejisu-Juaben District [12]

Data from the survey comprising the plants' scientific names, family, common name, part(s) used, growth habit, mode of preparation and administration as well as the frequency of citation and relative frequency of citation are presented on Tables 1 and 2. Seventeen plants belonging to 15 genera from 13 families were reported to be used as antidote for snakebite poisoning (Table 1). Ten plants belonging to nine genera from nine families were reported as snake repellents (Table 2).

Table 1. Plants used as antidote for snake-venom in Ejisu-Juabeng District, Ghana

Scientific name	Family	Common name	Life form	Part used	Preparation and Application	Voucher No.	FC[a]	RFC[b]
Allium cepa L.	Amaryllidaceae	Onion	Herb	Bulb	Crushed bulb/skin pasted on site of bite	KNUST/HM1/2020/B004	9.4	0.12
Allium sativum L.	Amaryllidaceae	Garlic	Herb	Bulb	Crushed bulb pasted on site of bite	KNUST/HM1/2020/B001	11.4	0.14
Amaranthus spinosus Linn.	Amaranthaceae	Thorny amaranth	Herb	Thorny part and leaves	Crushed leaves pasted on site of bite	KNUST/HM1/2021/L020	1.1	0.01
Anacardium occidentale L.	Anacardiaceae	Cashew	Tree	Bark	Crushed bark pasted on site of bite	KNUST/HM1/2019/R005	8.4	0.11
Azadirachta indica A. Juss.	Meliaceae	Neem	Tree	Leaf	Crushed leaves pasted on site of bite	KNUST/HM1/2019/L004	11.4	0.14
Bryophyllum pinnatum Lam.	Crassulaceae	Life plant	Herb	Sprout leaf	Crushed sprout leaves, pasted on site of bite	KNUST/HM1/2021/L021	1.1	0.01
Curcuma longa L.	Zingiberaceae	Turmeric	Herb	Rhizome	Crushed rhizome pasted on site of bite	KNUST/HM1/2021/B002	4.1	0.08
Dryopteris dilatate Hoffm.	Dryopteridaceae	Fern	Fern	Leaf	Crushed leaves pasted on site of bite	KNUST/HM1/2018/B008	1.1	0.01
Mimosa pudica L.	Fabaceae	Touch-me-not	Herb	Root	Dried powdered root, pasted on site of bite	KNUST/HM1/2018/R003	6.3	0.08
Moringa oleifera Lam.	Moringaceae	Moringa	Tree	Leaves, root bark	Crushed leaves or root bark powder pasted on site of bite	KNUST/HM1/2015/L031	2.1	0.03
Nicotiana tobacum L.	Solanaceae	Tobacco	Herb	Leaves	Leaf decoction drank by victim	KNUST/HM1/2018/L022	21	0.26
Paullinia pinnata L.	Sapindaceae	-	Shrub/woody climber	Whole plant	Burnt root or stem decoction drank by victim	KNUST/HM1/2018/L017	1.1	0.01
Rauwolfia serpentine (L). Benth. ex. Kurz	Apocynaceae	Snake root	Tree	Leaves, root	Aqueous leaf infusion drank by victim. Powdered root pasted on site of bite	KNUST/HM1/2015/L029	14.6	0.18
Spondias mombin L.	Anacardiaceae	Hog plum	Tree	Root bark, leaves	Crushed bark and/or leaves pasted on site of bite	KNUST/HM1/2021/R002	3.1	0.04
Viscum articulatum Burm. F.	Santalaceae	Leafless mistletoe	Herb	Leaves	Crushed leaves pasted on site of bite	KNUST/HM1/2021/L016	1.1	0.01
Viscum album L.	Santalaceae	Mistletoe	Tree	Leaves	Crushed leaves pasted on site of bite	KNUST/HM1/2021/L017	1.1	0.01
Voacanga Africana Stapf.	Apocynaceae	-	Tree	Sap in leaves, stem bark, root bark	Leaf sap licked by victim; powdered stem bark and root bark decoction drank by victim	KNUST/HM1/2017/S001	2.1	0.02

a: FC, frequency of citation; b: RFC, relative frequency of citation index

Table 2. Plants used as snake repellent in the Ejisu-Juabeng District, Ghana

Scientific name	Family	Common name	Life form	Part used	Preparation and Application	Voucher No.	FC[a]	RFC[b]
Allium cepa L.	Amaryllidaceae	Onion	Herb	Whole plant, bulb	Infusion of crushed bulb sprinkled on compound. Snake repelled by scent of plant	KNUST/HM1/2020/B004	14.7	0.18
Allium sativum L.	Amaryllidaceae	Garlic	Herb	Bulb, leaves	Crushed bulb infusion sprinkled on compound. Snake repelled by scent of plant	KNUST/HM1/2020/B001	16.8	0.21
Amarantus spinosus Linn.	Amaranthaceae	Thorny amarantus	Herb	Whole plant	Snake scared by presence of plant	KNUST/HM1/2021/L020	4.2	0.05
Argyreia nervosa Burm. F.	Convolvulaceae	Elephant creeper	Herb	Whole plant	Snake scared by creeping leaves of plant	KNUST/HM1/2017/W001	2.1	0.03
Cymbopogon citratus Stapf.	Poaceae	Lemon grass	Grass	Whole plant	Snake repelled by scent of plant	KNUST/HM1/2017/W002	10.5	0.13
Garnicia kola Heckel.	Clusiaceae	Bitter kola	Tree	Seeds	Powdered seed incised or rubbed on wrist before visiting snake prone area	KNUST/HM1/2017/SB011	13.7	0.17
Nicotiana tobacum L.	Solanaceae	Tobacco	Herb	Whole plant	Snake repelled by plant; Burnt leaves sprinkled on compound	KNUST/HM1/2018/L022	20	0.25
Ocimum sanctum Linn.	Lamiaceae	Holy basil	Herb	Whole plant	Snake repelled by strong scent of plant	KNUST/HM1/2017/W003	5.3	0.07
Plumeria alba L.	Apocynaceae	Nosegay	Tree	Whole plant	Snake repelled by strong scent of plant	KNUST/HM1/2017/W004	1.1	0.01
Sanseviera trifasciata Prain	Asparagaceae	Mother-in-law tongue/ snake plant	Herb	Whole plant	Snake scared by appearance of plant	KNUST/HM1/2017/W005	11.6	0.14

a: FC, frequency of citation; b: RFC, relative frequency of citation index

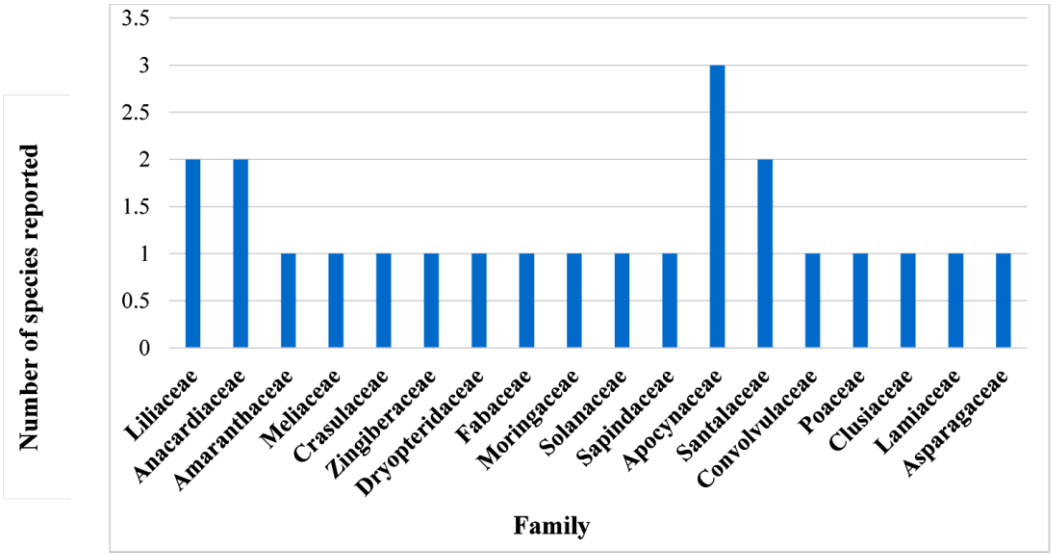

Figure 2. Families of anti-venin and snake repellent plants from in Ejisu-Juabeng District of Ghana

Four of the plants were used as both snake repellent and snake venom antidote. Plants belonging to the family Apocynaceae were found to be the most predominant (12.5%). Other plant families included Anarcardiaceae, Santalaceae and Amaryllidaceae (8.3% each) followed by Amaranthaceae, Fabaceae, Moringaceae, Sapindaceae, Crassulaceae, Zingeberaceae, Meliaceae, Dryopteridaceae, Poaceae, Asparagaceae, Solanaceae, Clusiaceae, Convolvulaceae and Lamiaceae (4.2% each) (Figure 2).The growth forms of plants documented included herbs (48%), trees (39%), shrubs (5%), ferns and grasses (4% each) (Figure 3). The high preference for the use of herbs for treating snakebites may be attributed to the availability of herbs as well as the ease of collection as compared to other growth forms [20].

For treatment of snakebite, the leaves were mostly used (58.8%) followed by roots (29.4%) (Figure 4). This practice is similar to reports from other countries that indicated the regular use of leaves and roots in traditional anti-venin therapies [20-22]. Other plant parts used were the bulbs, seeds, stem bark and rhizomes (Figure 4). For some plants more than one part could be used for treatment.

The most common mode of administration of medicines was topical (78.5%) in the form of crushed/chewed leaves or powdered barks and roots prepared as paste or poultice and applied by rubbing or tying onto the bite area. This mode of application was also common with anti-venin therapies reported from ethnobotanical studies from Nigeria, Kenya, Uganda and India [20, 23,24]. Oral dosages in the form of decoctions and infusions of leaves, stem barks and roots or directly licking the leaf sap were also applicable (21.4%).

The relative frequency of citation (RFC) index is indicative of the abundant use and widespread knowledge on a plant species among informants and is derived from the frequency of citation (FC). For antivenin plants, the RFC indices ranged from 0.01 to 0.26 (Table 1). The highest RFC was recorded for *Nicotiana tobacum* (0.26), followed by *Rauwolfia serpentine* (0.18) *Allium sativum* (0.14) and *Azadirachta indica* (0.14) (Table 1). For snake repelling plants, the most frequently mentioned were *Nicotiana tobacum* (0.25), *A. sativum* (0.21), *Allium cepa* (0.18), *Garcinia. Kola* (0.17), *Sanseviera trifasciata* (0.14), *Cymbopogon citratus* (0.13). It was recorded from respondents that the strong odour emanating from the aerial parts of the plant was mostly responsible for the snake-repelling effect of most of these plants. Infusions made from the crushed bulbs of onion and garlic were sprinkled in homes to repel snakes. Powdered bitter kola seeds were rubbed on exposed parts of the body or incised on the wrist when visiting snake-prone areas.

The results from this study have revealed that the use of plants in treatment of snakebites is common among the rural settlers of Ejisu-Juabeng. A recent study carried out by Steinhorst et al., in other parts of the Ashanti region reported the general use of herbs and animal-based formulations as well as spiritual consultations by traditional healers in the diagnosis and treatment of snakebites [15].

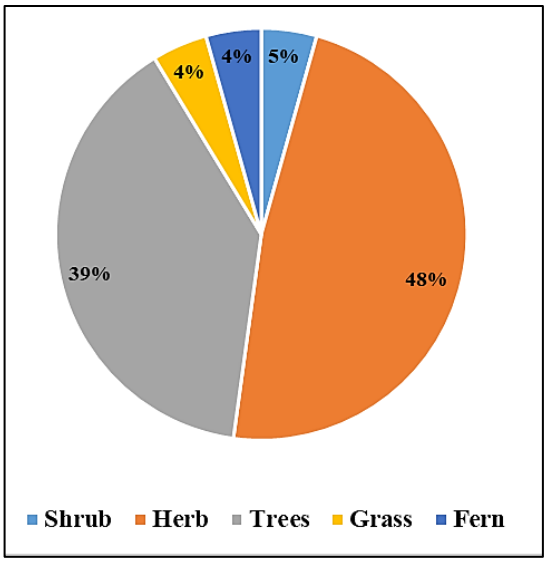

Figure 3. Growth habit of anti-venin and snake repellent plants from Ejisu-Juabeng District of Ghana

Meanwhile, specific herbs were not mentioned. The current report supports this previous report and further adds new knowledge on specific plants and how they are used in the traditional treatment of snakebites. Again, snake repellent plants have also been documented in the present report.

It was interesting to note that most of the plants reported to be used as antidote for snakebite in this study were also known to be used in other countries for the same purpose.

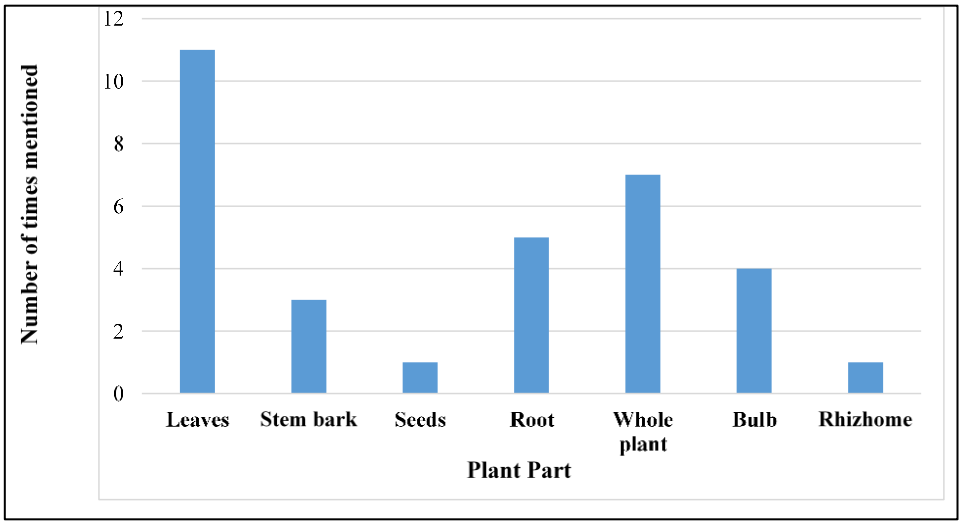

Figure 4. Plant parts used for anti-venin therapies and as snake repellent

Nicotiana tobacum, A*zadirachta indica*, *Rauwolfia serpentina*, *Mimosa pudica*, *Curcuma longa*, *Anacardium occidentalis*, *Allium sativum*, *Allium cepa* and *Moringa oleifera* are well known plant species recorded for their use as antidote for snake envenomation in various cultures [20-27]. Less commonly reported genera were *Amaranthus*, *Sanseviera*, *Spondias*, *Garcinia*, *Argyreia* and *Byrophyllum* [22,28]. The snake venom-neutralizing potential of some of the recorded plants against various crude snake venoms and purified toxins has been confirmed in previous studies [27,29-35]. All these reports suffice to support the use of these medicinal plants as antidote to snake venoms.

The current report on snake repelling plants is also similar to previous reports from Uganda, Nigeria, Sri Lanka and India, [21,22,36,37]. The snake repellent effect of *Garcinia kola* has been attributed to its astringent nature. The seeds may be spread in homes to repel snakes [37]. Renapurkar *et al*. also reported that extracts from the bulb of garlic (*Allium sativum*) and burnt leaves of tobacco (*Nicotiana tobacum*) repel snakes effectively [36]. The strong smell of volatile oils from the leaves of lemon grass (*Cymbopogon citratus*) has been linked to its snake and insect repelling effect [38, 39]. Due to its dense, sharp edged leaves, snakes avoid gliding through lemon grass to prevent cuts [21, 37]. *Ocimum* species including *O. gratissimum*, *O. carnum*, *O. basilicum*, *O. sanctum* are known as important sources of repellents and toxicants against many pests [40, 41]. In a previous study, extracts from *Allium sativum*, *Nicotiana tobacum* and oils from *Cymbopogon citratus* demonstrated remarkable snake repelling effect towards *Naja naja* (cobra) *Vipera russelli* (Russell's viper), and *Bungarus caeruleus* (krait), and two non-poisonous snakes, *Ptyas mucosus* (rat snake) and *Elaphe helena* (trinket snake) [36].

Plant constituents such as flavonoids, polyphenols, tannins, sterols, terpenoids, and polysaccharides have demonstrated potent anti-venin effects by neutralizing venom hydrolytic enzymes such as phospholipases, proteases and hyaluronidase [21,42]. Their mechanism of action is via selective binding to the active sites of the phospholipase A_2 enzyme or modifying conserved residues that are important to the catalytic activity the enzymes [46]. This blocks the expression of inflammatory, vasodilatory and vasoconstriction mediators during envenomation, thereby preventing the local effects such as local tissue damage, inflammation and myonecrosis, as well as the systemic effects such as dysfunction of vital organs and alteration in the coagulation components [42-44]. It is also important to note that the healing effect of these plants in snakebites could also be due to their common therapeutic properties such as anti-microbial, anti-edema, anti-oxidative, anti-pyretic and wound-healing activities.

Conclusion

This study has highlighted the importance of medicinal plants in the treatment of snakebites and as repellent to snakes in the Ejisu-Juabeng

District of Ghana. Such information is important as it can serve as evidential support for the clinical development of a number of medicinal plant remedies as adjuvant therapy.

Acknowledgments

The authors appreciate the technicians in the Department of Pharmacognosy, Faculty of Pharmacy and Pharmaceutical Sciences, KNUST, Kumasi.

Author contributions

Evelyn Asante-Kwatia and Abraham Yeboah Mensah conceptualized and designed the study; Evelyn Asante-Kwatia and Eunice Adomakowaa Fobi conducted the survey and material collection. All authors contributed to writing the manuscript, reviewed and approved the final version of the manuscript.

Declaration of interest

The authors declare that there is no conflict of interest. The authors alone are responsible for the accuracy and integrity of the paper content.

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Abbreviations

AV-C: Asna Antivenom C; CHRPE: Committee on Human Research, Publication and Ethics; FC: frequency of citation; IPNI: International Plant Name Index; RFC: relative frequency of citation