

Chapter

Medicinal Plants for Controlling of Gastrointestinal Nematodes in Scavenging Chickens: A Systematic Review

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Abstract

The review investigates medicinal plants published in peer-reviewed journals from 2000 to 2021. The objective of the review is to explore the use of IK to control gastrointestinal nematodes. Chickens contribute extensively to the livelihood of many communities by ensuring food security, women empowerment, and income provision. Scavenging chickens are, however, highly exposed to gastrointestinal nematodes (GIN). In total, 15 ethno-veterinary plant species belonging to 16 families were identified to control GIN. These included *Agave sisalana*, *Aloe forex*, *Gunnera perpensa* L., and *Aloe marlothii*. The value of these EVM lies in various chemical substances that possess properties such as alkaloids, saponins, and other phenolic compounds that fight diseases and parasites. Farmers collected plants from the bush, around the kraal, and along the homestead fence for easy access. Various administration methods and dosages were used. The use of plants to control nematodes in is attributed to the availability and ease of application. Medicinal plants, either as an alternative to anthelmintics or as a complement to conventional knowledge, need to be documented and promoted. It is necessary to evaluate the appropriate dosages of medicinal plants. Policies that govern the use and threats of medicinal plants need to be developed to conserve valuable remedies.

Keywords: ethnoveterinary remedies, conservation, indigenous knowledge, nematode infestation, natural products

1. Introduction

The demand for organic poultry products from free-range and deep-litter production systems is increasing [1]. Scavenging chickens significantly contribute to households with limited resources, particularly landless women, allowing them to receive healthcare and education. They contribute to sustainable development goals and food security by maintaining biodiverse genomes [2]. Chickens promote gender equality, particularly amongst disadvantaged groups and less helped areas of rural Africa [3]. They are not labour-intensive, can be reared as sideline enterprises, and demand less

space than larger animals such as cattle. Keeping chickens is advantageous to women as they manage poultry production and marketing without seeking permission from their husbands. The meat from scavenging chickens is highly preferred, thus suggesting that these genetic resources are promising options to enhance food security.

In large-scale production systems, the rearing of chickens is characterized by low productivity and high mortality [4]. Other challenges that resource-limited farmers face seriously include feed shortages [3]. Chickens are, thus, forced to roam around, scavenging around homesteads in contaminated areas with infective nematode eggs. Gastrointestinal nematodes are far from the most important parasites of chickens and remain the major factor hindering the successful production of village chickens [5]. Nematode infestations lead to decreased productivity and increased morbidity and mortality in chickens. The widespread occurrence of nematode infestations is linked to low management levels and poor hygiene [6, 7]. In intensive production systems, nematodes are usually controlled using anthelmintic; however, they are often out of reach for most farmers with limited resources as they are costly and, occasionally, inconsistently inaccessible. Using anthelmintic drugs has, however, been reported to lead to the development of nematode resistance against anthelmintic if overdosed and due to infrequent applications [3]. Consequently, this has increased the search for alternative control practices, such as using indigenous knowledge (IK). Indigenous knowledge is a set of perceptions, experiences, information, and behavior that guide community members in efficiently utilizing their natural resources [8].

The use of indigenous knowledge has been part of the day-to-day practices of resource-limited farmers for centuries [9]. Although for some years, IK has been neglected and secluded in development, the Department of Science and Technology has developed an IK policy with the main goal of strengthening the contribution of IK to social and economic development [10]. The use of IK and its contribution to veterinary care cannot be underemphasized. According to Luseba and Tshisikhawe, [11] an estimated population of 80% depends on IK in Africa, though IK is not recognized and documented. Ethno-veterinary remedies are effective and locally available to resource-limited farmers. Indigenous knowledge is sustainable and practically sound due to its ease of production and processing [10].

Developing indigenous knowledge systems (IKS) creates opportunities for conventional knowledge to complement and integrate with IK. Both systems have the potential to integrate into educational and lifelong learning frameworks, contributing to sustainable development and enhancing the veterinary care of chickens. Also, sharing IKS is important to ensure that it is used and preserved for the future. The paper explores existing information on the potential utilization of IK to control gastrointestinal nematodes in chickens. The review discusses the role of chickens in empowering women, enhancing food security, promoting organic meat production, and the significance of IK in managing nematode infestations in chickens and the common nematodes that infect them. The review also identifies potential areas that require more research concerning the exploitation of IK.

2. Materials and methods

The study focuses on using IK to control gastrointestinal nematodes in chickens. In this study, indigenous knowledge is the understanding and practices that local people use for survival. It has evolved through extensive trial and error and has been proven to handle changes in their environments [12] effectively. PRISMA guidelines (**Figure 1**)

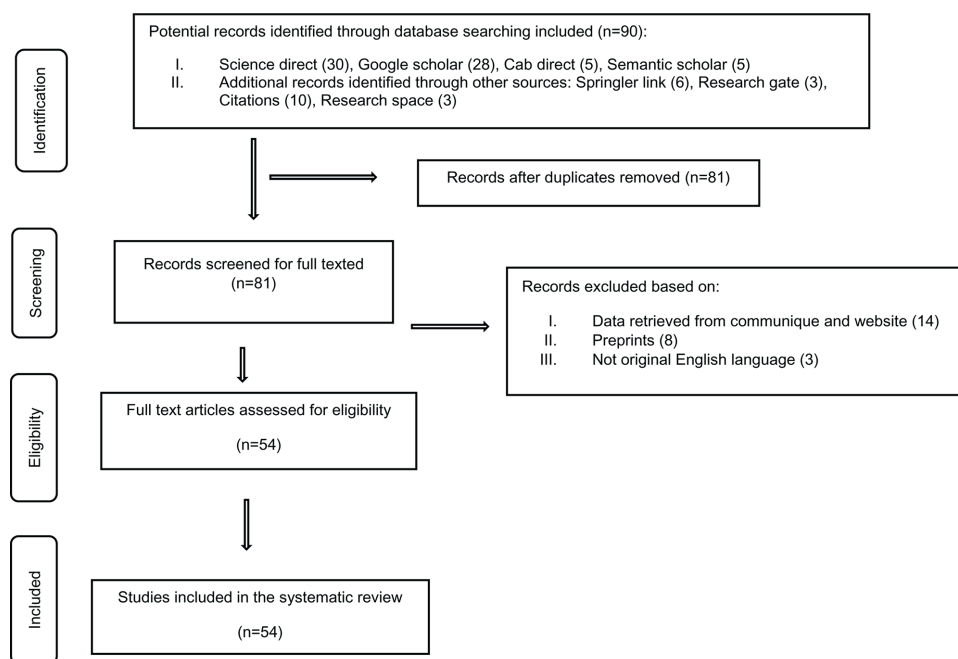


Figure 1.
 Diagram illustrating the process for screening literature.

were followed in the systematic review. Science Direct, Google Scholar, and Semantic Scholar were scientific databases used to search for the information. Additional searches were done through the reference lists of key articles to ensure a wide range of articles from different sources. Other sources, such as Springer links and Researchgate, were used in cases where articles were not obtainable from scientific databases. Research space was used in cases where the data found was obtained from a thesis. Keywords used during the article search included nematodes in chickens, medicinal plants, ethno-veterinary plants, indigenous knowledge, traditional animal healthcare, the role of chickens in resource-limited areas, and chicken production. During the search stage, preprints were not considered.

After completing the search, the authors (NGM, SZN, MVM, and MC) eliminated all duplicate articles. Before the qualitative synthesis, information such as article titles, authors, journals, publication type, English articles, indigenous knowledge of nematodes, and the functions and roles of chickens were gathered. Complete article texts were reviewed and dismissed based on the following exclusion criteria: studies providing data irrelevant to the research question, commune, and Website content from organizations such as FAO were rejected, and articles not in the original English language were rejected. Literature was synthesized into a quality metric utilizing four criteria: aim, methodology, results, and application. This review categorized the studies based on quality criteria, dividing them into categories: high referred to >75% of all sub-criteria satisfied, moderate 50–75% satisfied, and weak <50% of criteria fulfilled. The literature was used regardless of the research method employed (qualitative or quantitative). Research published in a language other than English presented abstract only or not peer-reviewed was left out. All pertinent articles were thoroughly reviewed and summarized utilizing a uniform data extraction table within a Word document (**Table 1**). The included articles were examined to find additional records.

Lead author, year	Location	Type of publication	Method used	Number of participants/ sample size (N)	Rank
Abdelqader et al. [1]	Germany	Research paper	<i>In vivo</i> and <i>in vitro</i> trial	225	H
Ajani et al. [13]	Nigeria	Review	–	–	W
Alam et al. [6]	Bangladesh	Research paper	<i>In vivo</i> and <i>in vitro</i> trial	–	W
Belete et al. [14]	Ethiopia	Review	–	–	M
Bettridge et al. [15]	Ethiopia	Research paper	Experimental	1056	H
Butboochoo and Wongsawad [7]	Thailand	Research paper	Experimental	120	H
Chander et al. [16]	India	Review	–	–	H
Dasgupta and Roy [17]	India	Research paper	<i>In vitro</i> trial	–	H
Giday et al. [18]	Ethiopia	Research paper	Semi-structured interviews	17	M
Gwala [19]	South Africa	MSc-Thesis	–	–	M
Idika et al. [20]	Nigeria	Research paper	Experimental	125	M
Jain et al. [21]	India	Review	–	–	W
Kabeer [22]	–	Review	–	–	W
Karumari et al. [23]	India	Research paper	Experimental	–	M
Khan et al. [24]	Pakistan	Research paper	Experimental	–	M
Katoch et al. [25]	India	Research paper	Experimental	125	H
Kumm [26]	Sweden	Short communication	Experimental	–	H
Kusina et al. [27]	Zimbabwe	Research paper	Semi-structured interviews	416	H
Lalchhandama et al. [5]	India	Research paper	Experimental	–	H
Matos Lopes et al. [28]	Brazil	Research paper	Experimental	–	H
Luseba and Tshisikhawe [11]	South Africa	Research paper	Focus group discussions	37	H
Malatji et al. [4]	South Africa	Research paper	Questionnaire	87	H
Mapiye et al. [29]	Zimbabwe	Review	–	–	H
Mapiye and Sibanda [30]	Zimbabwe	Research paper	Questionnaire	72	W
Melesse [31]	Germany	Review	–	–	M
Mitileni et al. [32]	South Africa	Review	–	–	M
Mathialagan [33]	India	Research paper	Questionnaire	200	W

Lead author, year	Location	Type of publication	Method used	Number of participants/ sample size (N)	Rank
Mkwanazi et al. [12]	South Africa	Research paper	Questionnaire	300	H
Mwale et al. [34]	Zimbabwe	Research paper	Questionnaire	150	M
Mwale and Masika [3]	South Africa	Research paper	Experimental	–	H
Mwale and Masika [3]	South Africa	Research paper	Experimental	14	M
McGlaw and Ellof [9]	South Africa	Review	–	–	H
Muchadeyi et al. [35]	Zimbabwe	Research paper	Questionnaire	100	M
Naphande and Chaudhari [36]	India	Research paper	Experimental	–	W
Ncobela and Chimonyo [37]	South Africa	Research paper	Questionnaire	239	H
Ndlela et al. [38]	South Africa	Research paper	Questionnaire	294	H
Puttalakshamma et al. [39]	India	Research paper	Experimental	100	M
Prakash et al. [40]	India	Review	–	–	W
Raza et al. [41]	Pakistan	Review	–	–	W
Siamba et al. [42]	Kenya	Research paper	Experimental	–	W
Subash et al. [43]	India	Research paper	Experimental	–	M
Swatson et al. [44]	South Africa	Research paper	Experimental	–	M
Symeonidou et al. [45]	Greece	Review	–	–	W
Sujith et al. [46]	India	Research paper	Experimental	–	M
Sugumar et al. [47]	India	Research paper	Experimental	–	M
Tesfaheywe et al. [48]	Ethiopia	Research paper	Semi-structured interviews	–	M
Tewari et al. [49]	India	Research paper	Semi-structured interviews	210	W
Uhuo et al. [50]	Nigeria	Research paper	Experimental	–	W
Vilakazi et al. [8]	South Africa	Research paper	Semi-structured interviews	400	H
Wuthijaree et al. [51]	Italy	Research paper	Experimental	–	H
Wong et al. [2]	Australia	Review	–	–	H
Zaman et al. [52]	Pakistan	Review	–	–	H

Table 1.
Study characteristics of the final qualified papers.

3. Results

Our search strategies identified a total of 90 articles. Following removing duplicates, an initial review of titles and abstracts was conducted to ascertain relevance, resulting in the identification of 56 articles that met the inclusion criteria for full-text screening. The review process is outlined in **Figure 1**, respectively. The data were taken from the articles provided and then examined:

1. Research attributes, study sites, and sample volume
2. Experimental conditions, such as the method used to collect data.

Out of 56 eligible articles, almost half of the studies were carried out in India (14), South Africa (12), Zimbabwe (6), Ethiopia (4), Nigeria (3), Pakistan (=3), Germany (2), and one article in Bangladesh, Thailand, Brazil, Italy, Greece, Sweden, Kenya, and Australia (**Table 1**).

4. Importance of chickens in rural economies

Women are generally owners and managers of chickens in resource-limited areas. Males largely own cattle and goats. Chickens contribute to livelihoods through women empowerment, ensuring seasonal food security, and providing cash and organic meat.

4.1 Women and youth empowerment

Women empowerment is fundamental to achieving gender equality. The empowerment of women is determined by the increase in economic benefits and role within the household economy [22]. It is also pertinent for increased productivity and improved health and nutrition. Scavenging chickens empower women socially, economically, physiologically, and technically [33]. Scavenging chickens are a valuable tool to empower women and improve their social status. Therefore, public institutions such as government and non-governmental agencies should promote farming by scavenging poultry. Farming chickens increases independent decision-making and enhances the involvement of women in their family affairs. It also promotes the socio-economic development of the rural sector. Participating in poultry-rearing projects positions rural women to develop good business skills. Such projects empower women by developing their economic benefits.

These chickens are raised with minimal financial inputs, feed supplements, land, and housing. Youth unemployment is one of the major challenges in the developing world. For example, in South Africa alone, the youth unemployment rate is estimated to be 66.5% in the current year, making it the leading country with the highest youth unemployment. The youth lack interest in agriculture due to inadequate finance, start-up capital, and their negative perception of agriculture in general [13]. Thus, youth prefer to seek employment opportunities in other sectors to economically empower themselves. Youth can have a safe social environment where they feel valued and supported and can share their ideas in decision-making. Furthermore, youth are interested in engaging and participating in socio-political processes to affect change while contributing to the empowerment of the community. Poultry production presents such opportunities.

4.2 Enhancing food and nutrition security using scavenging chickens

Food security is achieved when all people consistently have both the physical and economical means to access sufficient, safe, and nutritious food to fulfil their dietary requirements and preferences, enabling them to lead active and healthy lives at all times [32]. This definition is based on two interconnected pillars: availability and access to food. Wong et al. [2] characterized food availability as adequate quality foods that are culturally and socially acceptable within a specific community or society. Even if food is accessible, resource-limited households' insufficient purchasing ability and power make them suffer from food insecurity. While many countries are food secure nationally, most resource-limited households grapple with food insecurity. One potential approach to attaining household food security is to enhance the efficiency of scavenging chickens. This is ascribed to their products, such as meat and eggs, consumed at the household level without formal marketing channels. Providing meat and eggs from village chickens is the primary source of proteins to resource-poor households.

Eggs provide important nutrients, such as essential amino acids for human nutrition, and contribute 3–4% of the energy and protein an adult person requires daily [31]. A single egg provides 150.5 kilocalories of energy. It contains 12.4 grams of protein and 0.72 grams of carbohydrates. Regarding vitamins, an egg provides 158 micrograms of Vitamin A, 0.46 milligrams of Vitamin B2, and 1.05 milligrams of Vitamin E [19, 37]. Even though their consumption pattern cannot be quantified because they are consumed when there is a need. Scavenging chickens provide meat, which forms a source of protein in human diets. Consumers favour village chicken meat due to its superior taste and freshness, so much so that people in urban areas are willing to pay more for these birds at local markets (**Table 2**). In resource-limited communal production systems, chickens are kept by four out of five households [37]. Efforts are required to improve the livelihoods of communities by enhancing the availability and access to proper nutrition. Scavenging chickens provide cheap, readily harvestable protein-enriched white meat and eggs with highly digestible protein [30]. Chickens contribute by increasing the availability and accessibility of food supply and nutrients, leading to zero hunger, good health, and well-being [19].

4.3 Provision of household income and organic meat

Scavenging chickens are important to rural households in providing income, though their contribution to the household economy is relatively scant [30] and undocumented. Thus, their economic importance and contribution to food security are unappreciated nationally in most developing countries. Poultry contributes significantly to meeting welfare needs and raising the living standards of resource-limited communities. Chickens serve as reserves or assets, being sold to meet household needs, including school fees and medical costs [37]. Therefore, ensuring the effective advancement of chicken production systems is crucial, especially in this era of the rising human population, serving as a gateway to sustainable household income generation.

Organic meat is produced using ecological resources, such as natural by-products [26]. For example, feed produced without chemical pesticides, artificial fertilizers, and genetically modified organisms can be deemed organic [16]. Chickens raised organically exhibit natural behaviours, such as enjoying outdoor access year-round and using simple structures. Promoting the production of organic meat is vital because it plays an important role in ensuring an enduring supply of food. Producing organic meat from scavenging chickens has the capability to ensure nutritional

security for resource-limited households by converting unusable into usable products. Indigenous knowledge could influence the success of producing organic poultry meat. Indigenous knowledge and practices used in producing scavenging chicken products are wholesome, tasty, and safe meat and eggs that can markedly increase nutrition security for women, children, and the elderly.

5. Indigenous knowledge in controlling nematodes in scavenging chickens

Although using IK to control parasites and improve immunity and productivity is humongous, its utilization is slowly diminishing [38]. Farmers utilize IK to identify chickens affected by nematode infestation, including observing their behavior. In chickens infested with nematodes, farmers observed impaired growth, decreased output, diarrhoea, and reduced production in the flock [1]. Farmers monitor various signs of the bird’s recovery, including alertness, movement, feeding behavior, and the appearance of the green coloring in faeces, to confirm its full recovery.

Chickens recover at different times; some recover within 24 hours, some within days, while others recover within weeks [34]. The type of remedy, processing, and duration of application can influence the anthelmintic properties used so that some plant extracts act more swiftly than others. This might signify that different medicinal plants may have varying healing properties, thus accounting for the variability in the recovery time. Therefore, determining the active compounds of these plants would be of utmost interest. Resource-limited farmers use ethnoveterinary remedies over anthelmintic drugs because these remedies are locally available, effective, and convenient. The practice of using ethnoveterinary remedies to control nematodes dates back centuries. There are various kinds of medicinal plants that can manage chicken nematodes. *Aloe* is the most commonly utilized plant species [24], containing components such as *Aloe* leaf gel and exudates [32]. Other common plant species that farmers use are shown in **Table 2**.

Village chicken portions	% consumption by households		
	Male	Female	Children
Head	2.8	9.9	73.1
Feet	0.4	16.5	72.7
Neck	21.4	40.0	36.7
Thighs	43.8	53.7	5.7
Drumstick	47.9	47.1	4.9
Wings	47.5	45.0	14.0
Breasts	18.6	31.8	50.0
Back	29.3	38.4	28.9
Intestines and abdominal organs	16.1	11.1	57.4
Eggs	10.3	17.3	69.0

Source: Gwala [19].

Table 2.
Consumption of village chicken products in households.

6. Nematode species infesting chickens

Farmers with limited resources identify and categorize nematodes based on their colour schemes, form, dimensions, and preference sites. Farmers use IK to name nematode species using their various colour schemes and sizes. However, when it comes to nematode control, farmers understand that plant extracts have a wide spectrum, so no plant is specific for a particular nematode. Of the three helminth classes, nematodes are more important than cestodes and trematodes [24]. Nematodes are notably recognized amongst helminths for the extent of harm they inflict on chickens, especially during severe infestations [48]. Nematodes cause significant chronic illnesses and economic losses to farmers [1]. The three nematode species are *Ascaridia galli*, *Heterakis gallinarum*, and *Capillaria* [50]. *Ascaridia galli* is the most common nematode infecting chickens in terms of the number and percentage of infections it causes.

Idika et al. [20] highlighted that *A. galli* is the most common nematode and ranks most frequently found helminth species in the local chickens, at a rate of 22%, followed by *H. gallinarum* a prevalence of 12%, ranking fourth in the overall prevalence. The second most prevalent nematode was *Heterakis gallinarum*, comprising 28% of the total [50], with little pathogenicity. Katoch et al. [25] also identified *Ascaridia galli* as the most common helminth spp. (30%), followed by *Heterakis gallinarum* (24%), *Raillietina cesticillus* (19%) and *Raillietina echinobothrida* (14%) [25]. It is important to highlight that nematode infection rates depend on rainfall patterns, locality, soil type, and feed given to chickens. The widespread availability of intermediate hosts, such as beetles and houseflies, contributes significantly to the high incidence of *Heterakis gallinarum* amongst local scavenging chickens.

Ascaridia galli infests chickens of all age groups, although the most significant damage is usually observed in younger birds aged less than 12 weeks [14]. Furthermore, *Ascaridia galli* serves as a potential carrier for Salmonella infections. Chickens heavily infested with *Ascaridia galli* spp. experience decreased feed efficiency, resulting in weight loss. In severe cases, reduced egg production may occur [36]. During a heavy infestation, adult *Ascaridia galli* worms cause intestinal blockage, move up the oviduct, and may be found in eggs. Naphande and Chaudhari [36] reported that *Ascaridia galli* might secrete toxins that could harm the enzyme systems in the chicken's intestinal lining. The life cycle of *Ascaridia galli* does not involve an intermediate host. It lays eggs in the small intestine and proliferates rapidly.

The presence of *Heterakis gallinarum* enhances the danger of transmitting a pathogenic infection called *Histomonas meleagridis* [14]. After becoming infested with *Heterakis gallinarum*, the chicken experiences a thickening of the caecal wall, leading to cloacal dirtiness [50]. Bettridge et al. [15] reported that *Heterakis gallinarum* infestation suppresses the immune system. *Capillaria* species are highly pathogenic and are common in scavenging chickens [51]. In deep-litter systems, there is a growing build-up of infective eggs from *Capillaria* species. Severe infestations cause the oesophagus to thicken and the crop wall to inflame. In heavy infestations, chickens become emaciated, weak, and anaemic, and they excrete bloody diarrhoea and suffer from haemorrhagic enteritis. *Capillaria* species pose a threat to young birds under three months old because of their underdeveloped immunity, while adult birds can tolerate infestations [11]. Even though research has consistently reported the effects of nematodes on chicken productivity, the definite thresholds of nematode infestations have not been clearly defined. Therefore, additional research is needed. This will help producers comprehend and handle the interaction between nematode and their host, offering strategies for managing nematode infestations. It is necessary to identify management

strategies to decrease nematode infestation in chickens. Extension services may assist farmers by offering capacity-building initiatives in management.

7. Efficacy of medicinal plants used to control nematodes in chickens

Ethno-veterinary medicine (EVM) practices are widespread due to numerous socio-economic difficulties, especially the lack of sufficient veterinary services [12]. The worth of these EVM is found in various chemical compounds that can potentially reduce and kill nematode burden. Several medicinal plants possessing anthelmintic properties have been used to reduce nematode burden (**Table 3**). In total, 15 ethno-veterinary plant species belonging to 11 families were identified to control nematodes. The efficacy of EVM has been tested by grinding seeds, leaves, bark, or any other part of the plant that possesses active ingredients [52]. Techniques, such as mass spectrophotometer and liquid chromatography, have been used to identify active plant ingredients. Validation of plants against nematodes based on *in vitro* and *in vivo* studies is not the goal of all ethnoveterinary studies [53]. To promote the use of the ethno-veterinary in sustaining the health of scavenging chickens, participatory studies involving farmers need to be conducted, and appropriate validation studies should be designed to affirm claims made by IK custodians. *Aloe ferox*, *Gunnera perpensa* L., and *Agave sisalana* Perrine have successfully controlled nematodes [3] in chickens.

At a dosage of 100 mg/kg of *Aloe ferox*, the egg count was reduced by 81%. A notable reduction was observed in the 50 mg/kg dosage from the 7th to the 14th day (**Table 3**). A comparable pattern was observed on *Gunnera perpensa* L., whereas *Agave sisalana* Perrine decreased the egg count by 86% at 50 mg/kg dosage on day 7 and completely eliminated it by day 14. Kaingu et al. [53] tested the efficacy of *Aloe secundiflora* Engl. *in vitro*. The crude extracts were shown to inhibit the development of larval stages of *Ascarida galli*. Other plant species showing anthelmintic properties against nematodes include *Ozoroa reticulata* and *Strychnos spinosa* [34]. Other authors have reported plants that are specific to a particular helminth species, for example, *Vernonia amygdalina* [42], *Murraya koenigii* [46], and *Azadirachta indica* [41] are known to have properties that destroy *A. galli*. A study examining *in vitro* anthelmintic properties of *Bassia latifolia* found that an aqueous extract from dried seeds caused more mortality in adult *A. galli* than alcoholic extract.

Treatment	Dose (mg/kg)	Mean worm egg count ($\pm$ SE)			Egg count reduction (%)	
		Day			Day	
		0	7	14	7	14
<i>Aloe ferox</i>	50	1150.00 $\pm$ 934	350.00 $\pm$ 235	62.50 $\pm$ 453	96	83
	100	1312.50 $\pm$ 934	37.50 $\pm$ 244	375.00 $\pm$ 453	81	99
<i>Gunnera perpensa</i>	50	9400.00 $\pm$ 934	350.00 $\pm$ 244	13750 $\pm$ 453	91	89
	100	987.50 $\pm$ 934	25.00 $\pm$ 244	525.00 $\pm$ 453	71	92
<i>Agave sisalana</i>	50	262.50 $\pm$ 934	12.50 $\pm$ 244	62.50 $\pm$ 453	86	100
	100	212.50 $\pm$ 934	50.00 $\pm$ 244	150.00 $\pm$ 453	33	67

Source: Mwale and Masika [3].

Table 3.
Efficacy of indigenous medicinal plants in controlling nematodes of scavenging poultry.

Oil from *Piper betle* L. was administered at a dosage rate of 200 mg/kg body weight for a 24-hour interval and reduced worm burden by 13.9% after the first dose. *Piper betle* L., after a second dose of treatment, reduced the worm burden by 51.4%. Fruits from *Anacardium occidentale* L. were extracted with alcohol and aqueous extract (250 and 500 mg/ml) and showed significant anthelmintic properties at higher concentrations [41]. Both extracts showed anthelmintic activities in a dose-dependent manner, with the shortest time of paralysis. The aqueous extract of *Solanum torvum* fruits proved more effective, as it was lethal to the *Ascaridia galli* at a reduced concentration following 36 hours of exposure, compared to the leaves of *Sageraea grandiflora* [23]. However, during the initial 12–24 hours of exposure, the aqueous leaf extract of *S. grandiflora* proved more effective. The aqueous extract of *Agave sisal* waste demonstrated limited effectiveness against parasitic-stage parasites [54]. However, the extract exhibited moderate efficacy against both the eggs and free-living stages of the parasite without posing any toxicity risk to the goats [49]. Leaf extracts of *Eupatorium triplinerve* showed greater anthelmintic efficacy in both the study's worms compared to the standard albendazole [35].

8. Discussion

Scientific evidence of the contribution of IK to control nematodes in scavenging chickens amongst resource-limited farmers was reviewed [3]. Accessibility to a year-round provision of adequate nutrition remains a major challenge in developing countries. Amongst the most vulnerable groups are widows, women, children under the age of five, and lastly, elderly people. In communal areas, 35% of women earn income from poultry [2]. Chickens are favored among households as the most democratic and popular livestock species, as all members, including children, can own them. In addition, amongst resource-limited farmers, chickens contribute to food variability and diversity [35]. Although chickens are an asset to resource-limited households, several constraints that limit their contribution have been identified. These include housing, predation, low productivity exacerbated by the high prevalence of nematode infestation, and poor veterinary and extension services. As such, IK plays a vital role in improving and eradicating high nematode burdens. For the sustainable intensification of chickens in rural communal areas, there is a need to explore and understand the contribution of IKS to alleviating nematodes in chickens.

The findings from the current review provided insight into how chickens empower women and children and enhance food security by providing organic meat. The observation that chickens are used to empower women could be influenced by the fact that most chickens in the village are owned by females [32]. Women actively engage in various activities, assuming complementary roles and collaborating with their male counterparts, with their contribution surpassing that of men, particularly in chicken production. Women facilitate cleaning, feeding, vaccinating, and selling chickens and eggs [27]. This finding is, however, also contrary to Mapiye et al. [29]. As much as chickens contribute to food security, however, their eating behavior is usually skewed because of culture [19]. The bigger portions of the meat, such as thighs and breasts, are usually given to men rather than women and children. Such patriarchal structures may also contribute to children's malnutrition challenges in Africa and may need to be addressed. The type of production system chickens are kept in is also associated with sub-optimal management, predisposing chickens to high nematode infestation. Such findings agree with Mwale et al. [34] and Swatson et al. [44]. The high nematode

burden in chickens is even reported in other parts of the world, such as India and Pakistan [25]. These results are comparable to Puttalakshamma et al. [39], who reported 77.3 and 71% helminthic infections in local chickens, respectively. Since the advent of anthelmintic resistance and meat safety concerns, searching for alternative approaches to control nematodes has prompted the need to explore IKS (**Table 4**).

The study finds that using IK has proven effective and beneficial due to its active compound against nematodes. There is no risk of drug residues in poultry products

Scientific name	Family	Disease	Method of preparation	References
<i>Aloe maculata</i> (syn. <i>Aloe saponaria</i>)	Asphodelaceae	Internal worms	Leaf infusions	McGaw and Eloff [9]
<i>Aloe secundiflora</i>	Asphodelaceae	Parasites and diarrhoea	Infusion administered through drench	Kaingu et al. [53]
<i>Aloe marlothii</i>	Asphodelaceae	Parasites, diarrhoea	Leaves	McGaw and Eloff [9]
<i>Aloe ferox</i>	Asphodelaceae	Parasites and diarrhoea	Infusion made of leaves	Mwale and Masika [3]
<i>Acacia karroo</i>	Fabaceae	Intestinal parasites and diarrhoea	Bark and leaves	McGaw and Eloff [9]
<i>Agave sisalana</i>	Agavoideae	Internal worms	Leaves sliced and grounded	Mwale and Masika [3]
<i>Gunnera perpensa</i>	Gunneraceae	Internal parasites	Leaves sliced, grounded, put in water	Mwale and Masika [3]
<i>Sageraea grandiflora</i>	Fabaceae	Ascarida galli	Leaves	Karumari et al. [23]
<i>Centella asiatica</i>	Apiaceae	Internal worms	Cut the whole plant, boil, cool it, and give it to chickens to drink	Mwale and Masika [3]
<i>Xysmalobium undulatum</i> L. R. (Br.)	Apocynaceae	Internal parasites	Cut the whole plant, boil, cool it, and give it to chickens to drink	Mwale and Masika [3]
<i>Millettia grandis</i> (E.Mey.) Skeels	Fabaceae	Internal worms	Soak the leaves in cold water, then give birds to drink	Mwale and Masika [3]
<i>Vernonia colorata</i> (Willd.) Drake subsp. <i>colorata</i>	Asteraceae	Internal Worms	Take the roots and soak them until the color changes to dark brown (like coke), and give the animal 1 L	Luseba and Tshisikhawe [11]
<i>Acacia oxyphylla</i>	Leguminosae	Internal worms	Cut the bark and add to the water; allow it to release the darkish fluid and give chickens to drink	Symeonidou et al. [45]
<i>Alpinia galanga</i>	Zingiberaceae	Pheritima posthuma	Dried rhizome	Subash et al. [43]
<i>Eupatorium triplinerve</i>	Asteraceae	Internal worms	Cut the leaves and soak in the water	Symeonidou et al. [45]

Table 4.
Indigenous plants used for nematode control in scavenging chickens.

compared to synthetic anthelmintics [52]. Using locally available and cheap IK is the most sustainable method for limited households to control nematodes [35]. Using IK covers people's knowledge, methods, skills, and beliefs about the care of chickens and, through trial and error, uses this knowledge to control GIT parasites. Often at times farmers also include the use of Western medicine in combination with IK [3]. Plants from the genus *Aloe* have a long history of use in Africa to eradicate nematodes; however, no medication has been produced. This vividly reveals the need to decolonize veterinary structures as these organizations only accept Western medicine and disparage IKS. Research has consistently been conducted on the efficacy of ethno-veterinary plants against nematodes. However, there is still a lack of valid knowledge about compound activity and toxicology against nematodes and poultry hosts, hence the need for further investigations. *Aloe* species have been reported to possess numerous anthelmintic properties, such as antibacterial, antifungal, and antivenin [29]. These properties are thought to be responsible for paralysing nematodes and preventing their multiplication, respectively.

Acacia spp. has been reported to possess anthelmintic activity against *Ascarida galli*, though no scientific evidence is available for *Acacia karoo*. The degree of anthelmintic activity reported in *Sesbania grandiflora* leaves and *Solanum torvum* fruits aqueous extract could be due to the variations in phytochemicals, such as alkaloids, saponins, and tannins. The study also revealed that different plant parts are exploited during remedy preparation, and different methods are used to prepare plants. The primary plant parts used are roots, leaves, bark, fruits, as well as young shoots and flowers [41]. The efficacy of *Piper betle* L. could be attributed to the active ingredients present in plants, such as alkaloids, flavonoids, polyphenols, and terpenes. These phytochemicals may damage the nematode mobility and cuticle, thus causing paralysis or mortality of the parasites [45]. *Aloe secundiflora* L. is mainly utilized for its exudates and leaf gel, sourced from inner epidermal layers [53]. The secretions from *Aloe secundiflora* L. contain well-known phenolic compounds, including phenyl pyrones, anthrones, chromones, tannins, polysaccharides, phenolic compounds, and terpenoids, while the gel mainly consists of polysaccharides [45]. Compounds such as monoterpenes, which are part of essential oils, tend to disrupt the tubulin polymerization in the intestinal cells of the nematode, leading to their degeneration and death [21]. Substances such as tannins possess the ability to bind free protein in the digestive tract, limiting the availability of nutrients and thereby causing larval starvation [21]. In addition, tannins may cause a decrease in gastrointestinal metabolism by inhibiting oxidative phosphorylation, leading to larval death. The leaves of the *Azadirachta indica* L. plant hold significant medicinal value. This plant's chemical constituents include numerous biologically active substances, such as alkaloids, carotenoids, flavonoids, steroids, triterpenoids, ketones, and phenolic compounds [41].

The presence of secondary metabolites might decrease egg hatching, larvae development rate, and egg production by adult parasites. The use of the *Agave sisalana* plant is based on the richness of phytoconstituents responsible for potent medical activities, such as the presence of tannins, flavonoids, coumarins, steroids, and triterpenes [49]. Other authors have reported using *Agave sisalana* with other plants, particularly *M. pyriflora* roots and *Aloe* sp. leaves, to treat fowl pox in chickens [18]. *Eupatorium triplinerve* is widely used in folk medicine due to its analgesic, anticoagulant, anorectic, antiparasitic, anthelmintic, sedative, antifungal, and antibacterial properties. The major chemical groups of *E. triplinerve* are saponins, reducing sugars, alkaloids, steroids, triterpenoids, phenols, tannins, and flavonoids [28]. *Eupatorium triplinerve* revealed the presence of Coumarins and phenolic compounds as chemical

constituents. Phenolic compounds have anthelmintic and antiparasitic properties (Ascaris) [47]. Likewise, anthelmintics such as oxiclozanide, niclosamide, and bithionol are classified as synthetic phenols and have been proven to disrupt energy production in helminths. In the study by Subash et al. [43], it was found that the phenolic contents in extracts of *Eupatorium triplinerve* exhibited effects comparable to and even surpassed those found in *Alpinia galanga*. The same authors concluded that the anthelmintic activity of *Alpinia galanga* on *Ascaridia galli* has a specific activity, while *Eupatorium triplinerve* has a broad spectrum of anthelmintic activity when used on *Ascaris lumbricoides*.

The aerial parts and roots of *Centella asiatica* are used for medicinal purposes, and its chemical constituents have broad therapeutic benefits, including antimicrobial, anti-oxidant, anti-inflammatory, anticancer, neuroprotective, and wound healing properties [40]. Asiatic acid, asiaticoside, and madecassoside are the primary constituents contributing to their pharmacological value and are abundant in flavonoids and terpenoids. Centelloid was coined to reflect diverse secondary metabolites produced by plants, primarily pentacyclic, triterpenoid, and saponins. Analysis from the gas chromatography-mass spectrometry revealed that the essential oil of *C. asiatica* contained significant levels of P-cymene-(44%) and various other volatile compounds [40]. *Acacia* spp. are effectual anthelmintic, anti-bacterial, and antifungal agents. The most active components of this genus are condensed tannins (CTs), a type of phenolic secondary metabolites that seldom exhibit toxic effects. The genus also contains saponins like *Acaciaside A* and *B*, which have been proven to have nematocidal and cestocidal properties. *Acacia oxyphylla* is used widely against gastrointestinal worms in traditional rural medicine. *Acacia oxyphylla* is also responsible for altering the surface ultrastructure in cestodes [17]. The observation that farmers used roots, leaves, and barks during remedy preparation could be influenced by the seasonal effects as the growth of different plant forms varies with season. Indigenous knowledge custodians, however, do not recommend using roots as they can potentially destroy the whole plant.

9. Concluding remarks and further research

Using plant extracts to combat nematodes offers significant benefits, such as reducing contamination in meat and eggs. It can replace synthetic drugs, which pose numerous health risks, such as drug resistance in local pathogen populations and residues in poultry meat. Scavenging chickens play a crucial role in enhancing food security and empowering women while supplying nutritious organic meat. Promoting scavenging chickens could serve as a sustainable way of poverty reduction and improving food security at the household level in many developing countries. Scavenging birds are raised in outdoor production systems which are known to have a high burden of nematode infestations. Although farmers abundantly rely on ethno-veterinary remedies to mitigate nematode challenges, the drawbacks to medicinal plants include inconveniences in using or preparing remedies and the seasonal availability of most medicinal plants. Understanding the remedy preparation methods for treating chickens is crucial to reducing worm counts effectively.

Indigenous knowledge helps control nematodes and enhance both chicken immunity and production. This includes the widespread use of plants, such as *Aloe marlothii* A. berger and *Aloe maculata* All. However, their potential efficacy needs to be validated. It is necessary to evaluate suitable dosages for potential medicinal plants. Policies regulating the utilization and protection of medicinal plants need to

be implemented to ensure the preservation and future availability of ethnoveterinary remedies. Farmers' classification of diseases and treatments needs to be comprehended. Efforts are required to evaluate the potential nutritional advantages of these medicinal plants, as certain nutrients can enhance birds' immunity, thereby promoting recovery. Therefore, investigating the potential impact of these ethno-veterinary plants on the carcass attributes and meat quality of scavenging birds is essential. This could include potentially utilizing these ethno-veterinary plants as natural growth promoters. For example, plants such as *Lippia Javanica* leaves have been used as growth promoters in chickens. Other types of *Acacia* plants have been noted to improve the quality of meat. To ensure the safety of organic meat and egg production, biological activity or toxic effects of ethnoveterinary medicine need to be assessed.

There is also a need for the government and other research institutions to invest in studying how indigenous plant products can be commercially developed. They should also offer support to emerging businesses that sell these plants in formal markets. Other opportunities that need to be explored, such as promoting the development of processing skills of medicinal plants, are important because they will assist in plant conservation considering the global issues of climate change and plant species migrating to other areas. There is also a need to explore the development of business skills from IK; for example, in South Africa, the indigenous plant trade has been reported to be worth about 62 million annually. Indigenous plants are processed to make products sold in the informal markets, and such opportunities could be useful in eradicating household hunger. In addition, plants such as *Acacia* leaves and *marula* trees have been tested on meat and carcass quality, growth performance, and antioxidants of various species due to their nutritional contents, such as high protein content. This demonstrates that these plants provide anthelmintic properties and are highly esteemed as feed alternatives. Hence, investing in using plants for medicinal purposes could also lead to discovering plants useful to nutritionists as feed shortages are becoming erratic.

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Author's contributions

MC conceived the research idea. NGM reviewed papers and drafted the manuscript, and MVM, SZN, and MC edited the manuscript. MC and MVM did the critical revision of the manuscript.

Disclosure of potential conflict

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