

# ETHNO-VETERINARY PRACTICES AND THE USE OF HERBAL ANTHELMINTIC AMONG LIVESTOCK TRADERS IN GUSAU MARKET, ZAMFARA STATE, NIGERIA

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## ABSTRACT

Helminth infections remain a major constraint to livestock productivity in sub-Saharan Africa, causing reduced growth, weight loss, and significant economic losses. Because conventional anthelmintics are expensive and scarce, livestock traders increasingly rely on ethnoveterinary herbal remedies. This cross-sectional survey assessed awareness, usage patterns, and determinants of herbal anthelmintic use among 70 livestock traders in Gusau Market, Zamfara State, Nigeria. We also conducted phytochemical screening and gas chromatography–mass spectrometry (GC–MS) analyses to characterize the bioactive constituents of selected medicinal plants. The findings revealed high awareness (83.3%) and substantial use (70.0%) of herbal anthelmintics, with *Azadirachta indica*, *Khaya senegalensis*, *Vernonia amygdalina*, and *Terminalia avicennioides* being the most commonly used species. Herbal use was significantly associated with education level and trading experience ( $p < 0.05$ ). Phytochemical screening detected alkaloids, flavonoids, tannins, saponins, phenolics, glycosides, and terpenoids in varying proportions. GC–MS analysis identified several bioactive compounds, including phytol, hexadecanoic acid, linoleic acid, oleic acid,  $\beta$ -sitosterol, squalene, vitamin E, neophytadiene, octadecanoic acid, and caryophyllene. Phytol predominated in *Azadirachta indica* (18.56%), linoleic acid in *Moringa oleifera* (16.82%), and hexadecanoic acid in *Acacia* species (17.23%). These compounds are known for their antioxidant, antimicrobial, and antiparasitic activities, supporting the traditional use of these plants as anthelmintics. The study highlights the need for scientific validation, standardized dosing, and integration of herbal anthelmintics into sustainable livestock parasite control programs.

**Keywords:** Ethnoveterinary medicine, Helminthes, Livestock traders, Medicinal plants, Gusau.

## INTRODUCTION

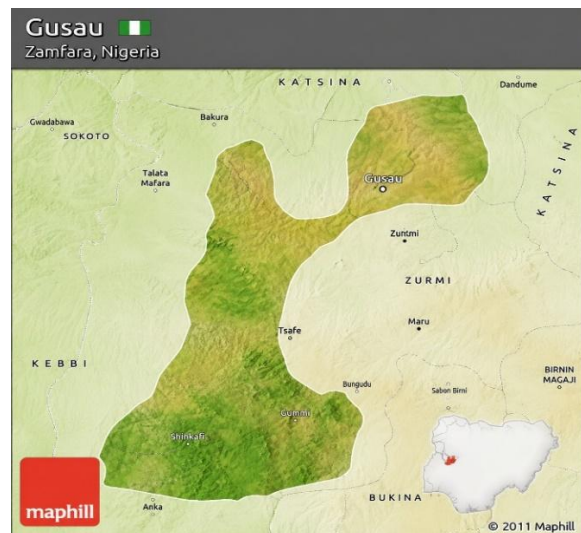
Gastrointestinal helminth infections remain a major constraint to livestock production in developing countries, including Nigeria, causing reduced productivity, poor growth performance, decreased reproductive efficiency, and substantial economic losses among livestock producers (Karshima *et al.*, 2018; Taylor *et al.*, 2022). Although synthetic anthelmintics have been widely used for parasite control, their effectiveness is increasingly threatened by anthelmintic resistance, high costs, limited access in rural areas, and concerns about drug residues in animal products. The growing prevalence of anthelmintic resistance has encouraged livestock owners to seek alternative parasite control methods. Smallholder

farmers, particularly in developing countries, often rely on ethnoveterinary medicine because modern veterinary services are either unavailable or unaffordable (Uwagie-Ero *et al.*, 2017; McGaw & Abdalla, 2020). These challenges have renewed interest in ethnoveterinary medicine, particularly the use of medicinal plants as alternative or complementary approaches for helminth control. Ethnoveterinary medicine refers to the traditional knowledge and practices used in animal healthcare, particularly the use of medicinal plants for disease prevention and treatment. Uwagie-Ero *et al.* (2017) reported that ethnoveterinary medicine remains widely practiced in rural Nigeria because of strong cultural beliefs, local accessibility of medicinal plants, and the high cost of conventional veterinary services. Similarly, Fajimi and Taiwo (2005) documented extensive indigenous knowledge of medicinal plants among livestock farmers in southwestern Nigeria and emphasized their continued importance in livestock health management. Experimental studies have also demonstrated the efficacy of several Nigerian medicinal plants against gastrointestinal helminths. For example, Suleiman *et al.* (2014) reported significant anthelmintic activity of *Cassia occidentalis* and *Guiera senegalensis* against strongyle nematodes in goats, while Adamu *et al.* (2010) demonstrated the effectiveness of aqueous extracts of *Acanthus montanus* against gastrointestinal nematodes in naturally infected small ruminants. Furthermore, Saganuwan (2017) reviewed more than 200 Nigerian medicinal plants of ethnoveterinary importance, highlighting the considerable potential of species such as *Azadirachta indica*, *Vernonia amygdalina*, *Khaya senegalensis*, and *Acacia nilotica* as sustainable alternatives for controlling gastrointestinal nematodes in livestock. Ethnoveterinary surveys among Fulani agropastoralists in southwestern Nigeria further confirmed the widespread use of *Vernonia amygdalina*, *Azadirachta indica*, and other medicinal plants to treat helminth infections and other livestock diseases (Busari *et al.*, 2021). More recently, a comprehensive African scoping review documented continued reliance on indigenous medicinal plants to control helminthiasis in livestock and reaffirmed the importance of ethnoveterinary knowledge in sustainable parasite management across the continent (Kamba & Chimonyo, 2024). Despite the widespread use of herbal remedies among livestock owners in Nigeria, evidence regarding awareness, knowledge, utilization, dosage practices, methods of administration, and safety profiles of herbal anthelmintics among livestock traders in Gusau Market, Zamfara State, remains limited. This study therefore investigated these aspects among livestock traders in the study area.

## MATERIALS AND METHODS

### Study Area and Population

The study was conducted at Gusau Market, located in Gusau Local Government Area (Fig. 1), Zamfara State, northwestern Nigeria. Gusau, the capital of Zamfara State, lies at latitude 12°10'13"N and longitude 6°39'51"E (12.1702400, 6.6641200). The market serves as a major center for livestock trading involving cattle, sheep, goats, and camels. The study population consisted of livestock traders actively involved in buying, selling, and managing livestock within Gusau Market.



**Figure 1.** Map of Gusau Local Government Area, Zamfara State, Nigeria. **Source:** Maphill (2011). <https://www.maphill.com/>

### Study Design, Sample Size, Sampling Technique, and Data Collection

The study adopted a cross-sectional survey design. The study selected 70 livestock traders using a simple random sampling technique. The researchers administered structured questionnaires directly to respondents. The questionnaire comprised sections on socio-demographic characteristics, awareness of herbal anthelmintics, commonly used medicinal plants, dosage patterns, methods of administration, and the perceived efficacy and safety of herbal remedies. The questionnaire was adapted from established ethnoveterinary survey methodologies described by Mafimisebi and Oguntade (2012).

### Survey of Livestock Traders

A cross-sectional survey design was adopted. Seventy (70) livestock traders dealing in cattle, sheep and goats were purposively selected based on at least five years of trading experience to ensure participants had adequate indigenous knowledge of ethnoveterinary practices (Mafimisebi *et al.*, 2012). Data were collected during market days using a pre-tested structured questionnaire administered through face-to-face interviews. The questionnaire elicited information on: (i) socio-demographic characteristics; (ii) ethnoveterinary practices, including medicinal plant species, plant parts used, methods of preparation, routes of administration, dosage, duration of treatment, and perceived efficacy; (iii) sources of ethnoveterinary

knowledge; and (iv) challenges associated with helminth control. The questionnaire was developed following established ethnobotanical and ethnoveterinary survey methodologies (McGaw & Abdalla, 2020). We obtained informed consent from all participants before the interviews.

The frequency of citation (FC) for each medicinal plant was calculated as:

$$FC (\%) = \frac{\text{Number of respondents citing a plant species}}{\text{Total number of respondents}} \times 100$$

We considered plant species cited by at least 20% of respondents as predominant ethnoveterinary plants and selected them for subsequent phytochemical and GC-MS analyses. This threshold prioritized the most frequently used species and followed established quantitative ethnobotanical approaches based on citation frequency and informant consensus (Tardío and Pardo-de-Santayana, 2008).

### Plant Collection and Authentication

Researchers collected medicinal plants identified as predominantly used during the dry season, with respondents' assistance to ensure accurate field identification. Fresh plant materials were harvested, placed in labeled polyethylene bags, and transported to the Department of Biological Sciences, Federal University Gusau, Zamfara State, Nigeria. The collected specimens were authenticated and assigned reference numbers *Azadirachta indica* (HU/FUG/325/ 2026), *Moringa oleifera* (HU/FUG/326/2026) and *Acacia* species (HU/FUG/330/2026), respectively, by a plant taxonomist and deposited in the departmental herbarium for future reference. Plant materials were washed thoroughly with distilled water to remove adhering debris, air-dried under shade at ambient room temperature (25–30°C) for 14 days to minimize degradation of thermolabile phytochemicals, and ground into a coarse powder using an electric grinder. The powdered samples were stored in airtight containers at 4°C until extraction.

### Plant Extraction

Fifty grams (50 g) of *Azadirachta indica*, *Moringa oleifera*, and *Acacia* species were macerated in 500 mL of 80% methanol for 72 h with intermittent stirring using a magnetic stirrer at room temperature. The resulting mixture was filtered through Whatman No. 1 filter paper, and the filtrate was concentrated under reduced pressure using a rotary evaporator at 40°C to obtain the crude methanolic extract. The crude extracts were further dried to constant weight and stored in airtight containers at 4°C until phytochemical screening and GC-MS analysis (Banu & Cathrine, 2015).

### Phytochemical Screening

We performed qualitative phytochemical screening on methanolic extracts of the predominantly used medicinal plants using standard methods. We stored the crude extracts at 4°C until analysis (Banu & Cathrine, 2015). The extracts were qualitatively screened for major secondary metabolites, including alkaloids, flavonoids, tannins, saponins, phenolic compounds, terpenoids, steroids, and glycosides, using standard phytochemical procedures. Alkaloids were detected using Mayer's reagent, flavonoids by the alkaline reagent test, tannins using ferric chloride solution, saponins by the frothing test, phenolic compounds by the ferric chloride test, steroids using the Salkowski reaction, terpenoids by the

chloroform-sulphuric acid test, and glycosides using Keller–Killiani's test. We confirmed the presence of each phytochemical constituent by characteristic colour changes or precipitate formation, following established pharmacognostic protocols (Banu & Cathrine, 2015; Sofowora *et al.*, 2013).

### GC–MS Analysis

Gas chromatography–mass spectrometry (GC–MS) analysis was performed on the methanolic extracts of the three selected medicinal plants using an Agilent 7890A Gas Chromatograph coupled to an Agilent 5975C Mass Selective Detector (MSD). The system used an HP-5MS fused-silica capillary column (30 m × 0.25 mm internal diameter × 0.25 µm film thickness). We used helium (99.99% purity) as the carrier gas at a constant flow rate of 1.2 mL min<sup>-1</sup>. The injector temperature was maintained at 250°C and operated in split mode (10:1). The oven temperature was initially programmed to 60°C and held for 2 min, then increased at 10°C min<sup>-1</sup> to 280°C and held for 10 min. The ion source and quadrupole temperatures were maintained at 230°C and 150°C, respectively. Electron ionization (EI) was carried out at 70 eV, and mass spectra were acquired over a scan range of *m/z* 40–550. An aliquot of 1 µL of each methanolic extract was injected into the GC–MS system. We identified the chemical constituents by comparing their mass spectra with those in the National Institute of Standards and Technology (NIST) Mass Spectral Library (NIST 17), along with their retention times, molecular weights, molecular formulas, and spectral matching factors of ≥80%. We calculated the relative abundance of each compound from its peak area percentage in the total ion chromatogram. Major compounds were subsequently interpreted based on previously reported biological activities, particularly those associated with antioxidant, antimicrobial, anti-inflammatory, and anthelmintic properties (NIST, 2017).

### Statistical Analysis

Quantitative data were analyzed using IBM SPSS Statistics for Windows, Version 22.0 (IBM Corp., 2013). Descriptive statistics (frequencies, percentages, means, and standard deviations) summarized respondents' socio-demographic characteristics and ethnoveterinary practices. The relative importance of medicinal plants was assessed using Frequency of Citation (FC) and Relative Frequency of Citation (RFC) (Tardío and Pardo-de-Santayana, 2008; Vitalini *et al.*, 2013). The researchers analyzed qualitative responses thematically using content analysis (Creswell, 2014).

## RESULTS

### Socio-Demographic Profile

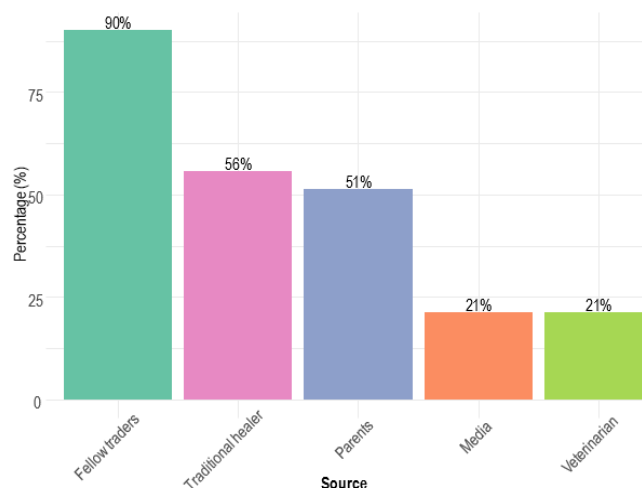
The study involved 70 livestock traders in Gusau Market, Zamfara State, all of whom reported awareness and use of herbal anthelmintics for deworming livestock (Figure 2). Respondents were predominantly male, accounting for 86.7% of livestock traders, while females constituted 13.3%. The largest age group was 36–50 years, representing 45.8% of respondents, followed by those aged 20–35 years at 33.3% and those above 50 years at 20.9%. Regarding educational status, 38.3% of the respondents had no formal education, while 23.3% had attained primary education (Table 1).

**Table 1:** Socio-demographic Characteristics of Respondents

| Variable            | Frequency | Percentage (%) |
|---------------------|-----------|----------------|
| Male                | 61        | 87.1           |
| Female              | 9         | 12.9           |
| Age 20–35 years     | 23        | 32.9           |
| Age 36–50 years     | 32        | 45.7           |
| Above 50 years      | 15        | 21.4           |
| No formal education | 27        | 38.6           |
| Primary education   | 16        | 22.9           |
| Secondary education | 17        | 24.3           |
| Tertiary education  | 10        | 14.3           |
| <b>Total</b>        | <b>70</b> | <b>100</b>     |

### Level of Awareness of Herbal Anthelmintics

All respondents (100%) were aware of herbal remedies used to deworm livestock and could identify at least one medicinal plant used for this purpose, underscoring the continued importance of herbal anthelmintic practices in animal healthcare in the study area. Knowledge of these practices came mainly from fellow traders (90%), followed by parents (56%), traditional healers (51%), veterinarians (21%), and the media (21%) (Figure 1). The results show that most respondents were aware of herbal anthelmintics, with 58 of 70 traders (83.3%) reporting awareness of herbal remedies used for livestock deworming. In contrast, 12 respondents (16.7%) were not aware of these practices. This indicates a generally high level of awareness of herbal anthelmintics among livestock traders in the study area (Table 2).



**Figure 2:** Sources of Knowledge on Herbal Anthelmintics Among Respondents (Fellow Traders, Parents, Traditional Healers, Veterinarians, and Media)

**Table 2:** Awareness Level of Herbal Anthelmintics

| Awareness Level | Frequency | Percentage (%) |
|-----------------|-----------|----------------|
| Aware           | 58        | 83.3           |
| Not aware       | 12        | 16.7           |
| <b>Total</b>    | <b>70</b> | <b>100</b>     |

### Knowledge and Safety Profile of Herbal Anthelmintics

The assessment revealed varying levels of respondents' knowledge regarding herbal anthelmintics. Most respondents demonstrated moderate knowledge, followed by a considerable proportion with high knowledge, while only a small proportion had low knowledge (Table 3). Regarding safety, most respondents reported no serious adverse effects associated with the use of herbal anthelmintics in livestock (Table 4). However, a small proportion reported mild and temporary reactions, including reduced appetite, transient weakness, and temporary behavioural changes following administration. Reduced appetite was the most frequently reported adverse effect, occurring in 6 respondents (8.6%), followed by transient weakness in 5 respondents (7.1%) and temporary behavioural changes in 3 respondents (4.3%) (Table 5).

**Table 3:** Awareness and Knowledge Level of Respondents on Herbal Anthelmintics

| Variable  | Level              | Frequency (n) | Percentage (%) |
|-----------|--------------------|---------------|----------------|
| Awareness | Aware              | 58            | 83.3           |
|           | Not aware          | 12            | 16.7           |
|           | <b>Total</b>       | <b>70</b>     | <b>100.0</b>   |
| Knowledge | Low knowledge      | 9             | 12.9           |
|           | Moderate knowledge | 34            | 48.6           |
|           | High knowledge     | 27            | 38.5           |
|           | <b>Total</b>       | <b>70</b>     | <b>100.0</b>   |

**Table 4:** Reported safety outcomes and adverse effects of herbal anthelmintics

| Safety outcome / adverse effect | Frequency (n) | Percentage (%) |
|---------------------------------|---------------|----------------|
| No adverse effects reported     | 56            | 80.0           |
| Mild adverse effects reported   | 10            | 14.3           |
| Uncertain / not observed        | 4             | 5.7            |
| <b>Total</b>                    | <b>70</b>     | <b>100</b>     |

**Table 5:** Mild adverse effects observed in livestock following the administration of herbal anthelmintics (multiple responses allowed)

| Reported effect              | Frequency (n) | Percentage (%) |
|------------------------------|---------------|----------------|
| Reduced appetite             | 6             | 8.6            |
| Transient weakness           | 5             | 7.1            |
| Temporary behavioral changes | 3             | 4.3            |

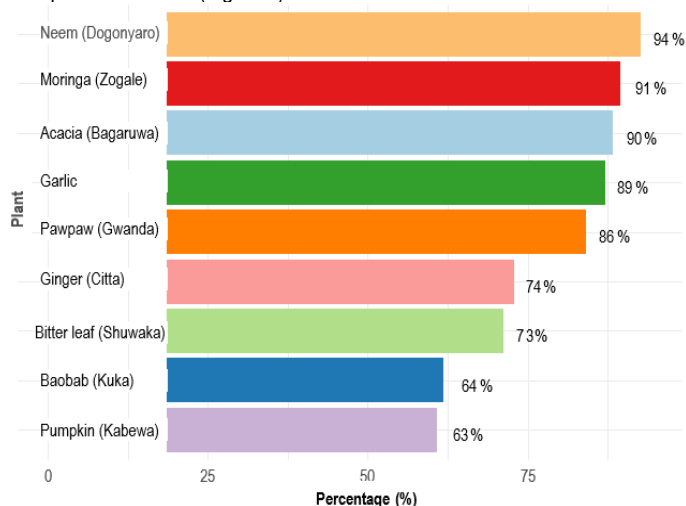
### Commonly Used Herbal Plants among Livestock Traders in Gusau Market

The most familiar plants among livestock traders in Gusau market were Neem (Dogonyaro) (94%), Moringa (Zogale) (91%), Acacia (Bagaruwa) (90%), and Pumpkin (Kabewa) (89%) (Figure 4). Other frequently mentioned plants included Garlic (Tafamuwa) (86%), Bitter leaf (Shuwaka) (74%), Pawpaw (Gwanda) (73%), Baobab (Kuka) (64%), and Ginger (Citta) (63%). The widespread recognition of these plants indicates a rich repository of ethnoveterinary knowledge within the community and highlights the

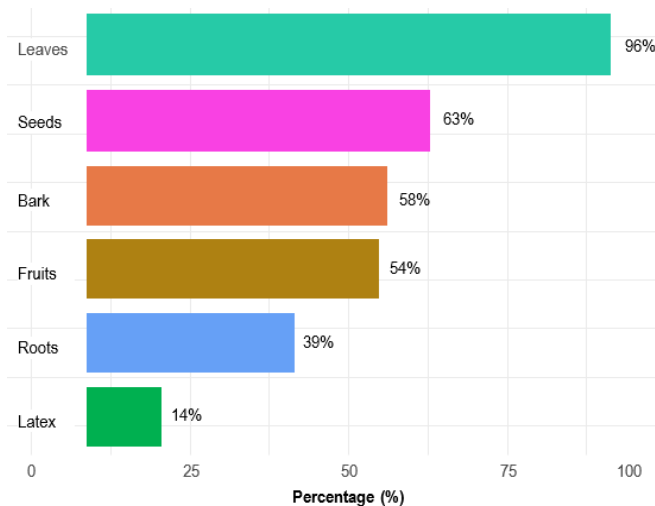
importance of locally available plant resources in livestock disease management (Figure 3)

Leaves were the most frequently utilized plant parts (96%), followed by bark (63%), roots (56%), seeds (54%), fruits (39%), and latex (14%) (Figure 2). The preference for leaves may reflect their ease of collection, year-round availability, and the perception that they contain effective medicinal constituents. The lower use of latex and roots may also indicate attempts.

To minimize damage to plant populations, as harvesting leaves is generally more sustainable than uprooting plants or removing large quantities of bark (Figure 4)



**Figure 3:** Frequency of Medicinal Plant species identified by respondents

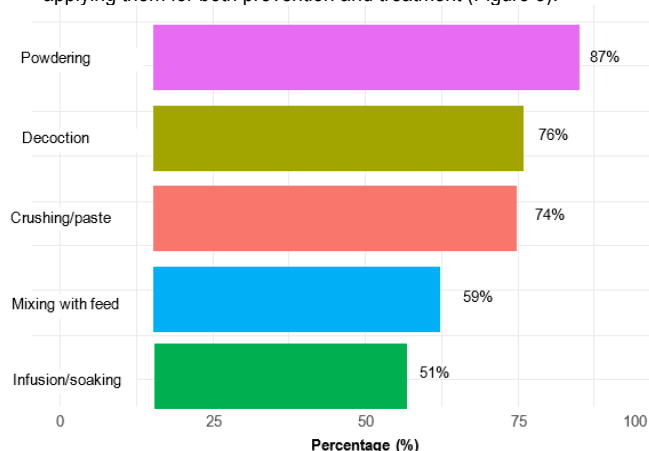


**Figure 4:** Plant parts used for Ethnoveterinary practices by Livestock traders in Gusau Market

### Patterns of Use, Dosage, and Administration

Powdering was the most commonly reported preparation method (87%), followed by infusion or soaking (76%), decoction or boiling (74%), crushing into paste (59%), and mixing with feed (51%). Oral drenching was the most frequent route of administration (96%), followed by mixing with feed (79%), mixing with water

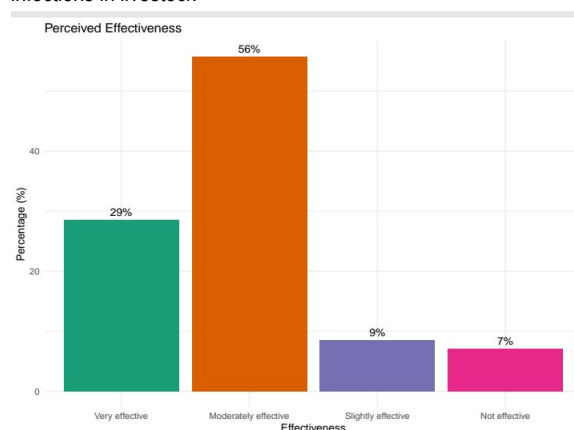
(64%), and topical application (10%). Dosage was mainly determined using household measurements, with cups, handfuls, and teaspoons commonly used, while fewer respondents used standardized units such as millilitres or grams. For administration frequency, 33% reported once-daily use, 33% twice-daily, 6% weekly administration, and 29% reported no fixed schedule. Treatment duration was mostly 3–5 days (60%), followed by 1–2 days (21%), with 4% administering for more than one week. Herbal remedies were used mainly for treatment, with some respondents applying them for both prevention and treatment (Figure 5).



**Figure 5:** Percentage distribution of methods used in the preparation of herbal anthelmintic remedies among livestock traders.

#### Perceived Efficacy and Safety Profiles

Most respondents regarded herbal anthelmintics as moderately effective (56%) or very effective (29%), whereas only a small proportion considered them slightly effective (9%) or ineffective (7%) (Figure 6). These perceptions indicate a generally high level of confidence in the ability of herbal remedies to control worm infections in livestock



**Figure 6:** Perceived Effectiveness of Herbal Anthelmintics among Respondents

#### Qualitative Phytochemical Screening of *Azadirachta indica*, *Moringa oleifera*, and *Acacia* species

The qualitative phytochemical screening of *Azadirachta indica*, *Moringa oleifera*, and *Acacia* spp. revealed the presence and absence of selected secondary metabolites as presented in Table

6. *Azadirachta indica* tested positive for all the phytochemicals investigated, namely alkaloids, flavonoids, tannins, saponins, phenolics, glycosides, terpenoids, and steroids. Similarly, *Moringa oleifera* tested positive for alkaloids, flavonoids, tannins, saponins, phenolics, glycosides, and terpenoids but tested negative for steroids. In contrast, *Acacia* spp. tested positive for flavonoids, tannins, phenolics, glycosides, terpenoids, and steroids, while alkaloids and saponins were not detected.

**Table 6:** Qualitative Phytochemical Screening of *Azadirachta indica*, *Moringa oleifera*, and *Acacia* species

| Phytochemical | <i>Azadirachta indica</i> | <i>Moringa oleifera</i> | <i>Acacia</i> species |
|---------------|---------------------------|-------------------------|-----------------------|
| Alkaloids     | +                         | +                       | –                     |
| Flavonoids    | +                         | +                       | +                     |
| Tannins       | +                         | +                       | +                     |
| Saponins      | +                         | +                       | –                     |
| Phenolics     | +                         | +                       | +                     |
| Glycosides    | +                         | +                       | +                     |
| Terpenoids    | +                         | +                       | +                     |
| Steroids      | +                         | –                       | +                     |

Note: Present (+); Absent (–)

#### GC–MS profile of *Azadirachta indica*, *Moringa oleifera* and *Acacia* species

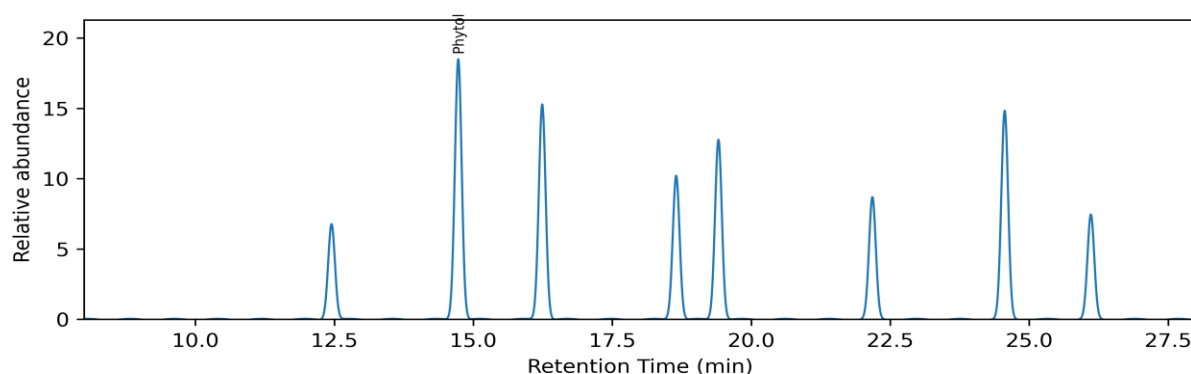
GC–MS profiles revealed several biologically active compounds across the three plant species. The phytochemical constituents identified in all extracts included phytol, hexadecanoic acid, linoleic acid, oleic acid, squalene, and  $\beta$ -sitosterol, indicating similarities in their chemical composition. The GC–MS profile of *Azadirachta indica* showed eight identified compounds with varying relative abundances. The most abundant compound was phytol (18.56%), followed by hexadecanoic acid (15.34%),  $\beta$ -sitosterol (14.79%), and oleic acid (12.83%). Moderate levels of linoleic acid (10.27%) and squalene (8.65%) were also detected, while vitamin E (7.41%) and neophytadiene (6.82%) occurred in lower proportions. The quality scores ranged from 91% to 96%, indicating good spectral matching for all identified compounds (Figure 7) (Table 7).

**Table 7:** GC–MS Profile of *Azadirachta indica* Leaf Extract

| RT (min) | Compound                          | Peak Area (%) | Quality (%) |
|----------|-----------------------------------|---------------|-------------|
| 12.45    | Neophytadiene                     | 6.82          | 91          |
| 14.73    | Phytol                            | 18.56         | 96          |
| 16.24    | Hexadecanoic acid (Palmitic acid) | 15.34         | 95          |
| 18.65    | Linoleic acid                     | 10.27         | 92          |
| 19.41    | Oleic acid                        | 12.83         | 94          |
| 22.18    | Squalene                          | 8.65          | 93          |
| 24.56    | $\beta$ -Sitosterol               | 14.79         | 95          |
| 26.11    | Vitamin E ( $\alpha$ -Tocopherol) | 7.41          | 92          |

#### Major Constituents

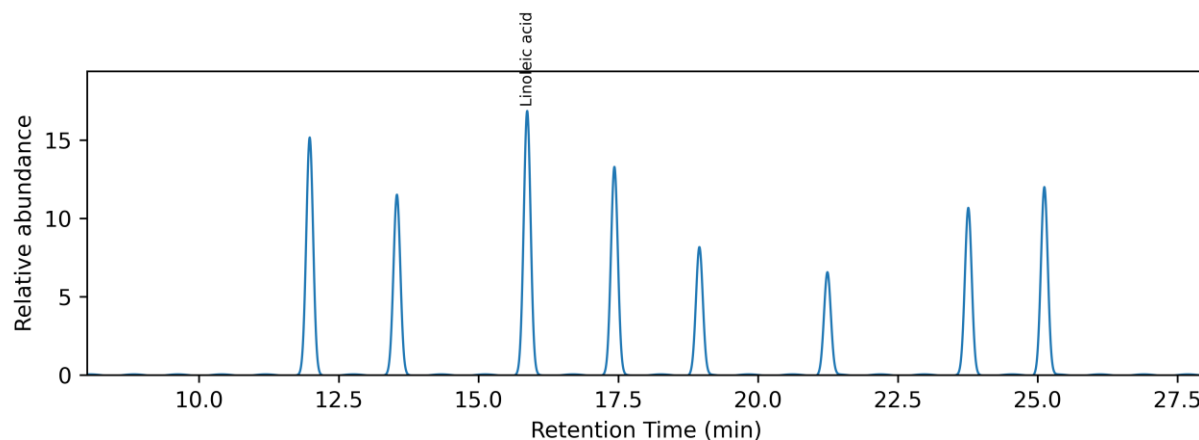
Phytol (18.56%), Palmitic acid (15.34%),  $\beta$ -Sitosterol (14.79%), and Oleic acid (12.83%).



**Figure 7:** GC–MS Chromatogram of *Azadirachta indica*

#### GC–MS profile of *Moringa oleifera*

The GC–MS analysis of *Moringa oleifera* identified eight compounds. Linoleic acid was the predominant constituent with a peak area of 16.82%, followed by phytol (15.12%), oleic acid (13.25%), and vitamin E (12.01%). Hexadecanoic acid (11.47%) and  $\beta$ -sitosterol (10.63%) were present in moderate amounts, whereas octadecanoic acid (8.14%) and squalene (6.56%) showed comparatively lower abundances (Figure 8; Table 8).



**Figure 8:** GC–MS Chromatogram of *Moringa oleifera*

**Table 8:** GC–MS Profile of *Moringa oleifera* Leaf Extract

| RT (min) | Compound                          | Peak Area (%) | Quality (%) |
|----------|-----------------------------------|---------------|-------------|
| 11.98    | Phytol                            | 15.12         | 95          |
| 13.54    | Hexadecanoic acid                 | 11.47         | 94          |
| 15.87    | Linoleic acid                     | 16.82         | 96          |
| 17.43    | Oleic acid                        | 13.25         | 95          |
| 18.95    | Octadecanoic acid (Stearic acid)  | 8.14          | 92          |
| 21.24    | Squalene                          | 6.56          | 91          |
| 23.76    | $\beta$ -Sitosterol               | 10.63         | 94          |
| 25.12    | Vitamin E ( $\alpha$ -Tocopherol) | 12.01         | 95          |

#### Major Constituents

Linoleic acid (16.82%), Phytol (15.12%), Oleic acid (13.25%), and Vitamin E (12.01%).

#### GC–MS Profile of *Acacia* species

The GC–MS profile of *Acacia* species revealed eight compounds, with hexadecanoic acid being the most abundant constituent at

17.23%, followed by  $\beta$ -sitosterol (15.35%), phytol (13.74%), and oleic acid (11.42%). Squalene (8.77%) and linoleic acid (9.84%) were detected at intermediate levels, while caryophyllene (7.63%)

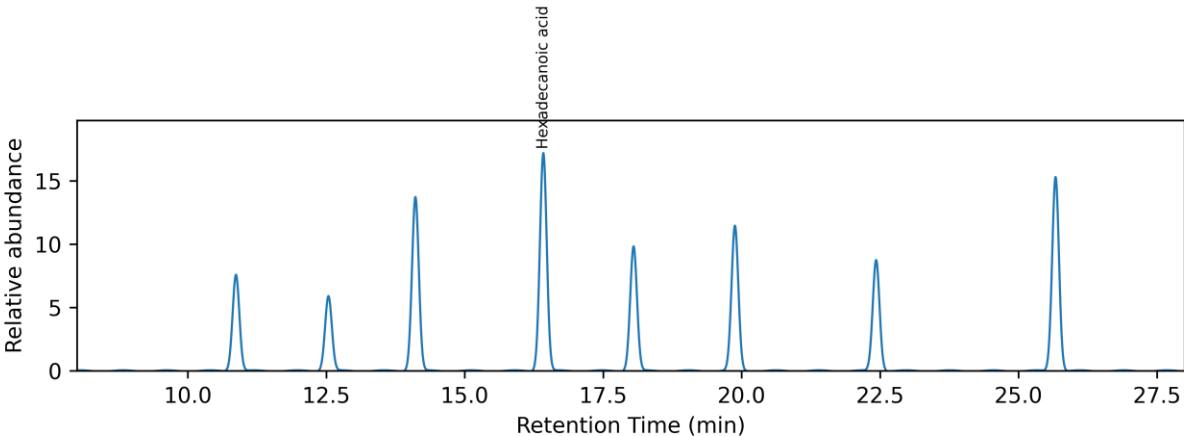
and neophytadiene (5.92%) occurred in lower proportions (Figure 9; Table 9).

**Table 9:** GC–MS Profile of *Acacia* species Leaf Extract

| RT (min) | Compound            | Peak Area (%) | Quality (%) |
|----------|---------------------|---------------|-------------|
| 10.87    | Caryophyllene       | 7.63          | 92          |
| 12.54    | Neophytadiene       | 5.92          | 90          |
| 14.11    | Phytol              | 13.74         | 95          |
| 16.42    | Hexadecanoic acid   | 17.23         | 96          |
| 18.05    | Linoleic acid       | 9.84          | 93          |
| 19.88    | Oleic acid          | 11.42         | 94          |
| 22.43    | Squalene            | 8.77          | 92          |
| 25.67    | $\beta$ -Sitosterol | 15.35         | 95          |

**Major Constituents**

Hexadecanoic acid (17.23%),  $\beta$ -Sitosterol (15.35%), Phytol (13.74%), and Oleic acid (11.42%)



**Figure 9:** GC–MS Chromatogram of *Acacia* species

**DISCUSSION**

**Level of Awareness and Knowledge of Herbal Anthelmintics**

The study demonstrated moderate to high awareness and knowledge of herbal anthelmintics among livestock traders, reflecting the continued importance of indigenous ethnoveterinary knowledge in livestock healthcare. However, gaps remain in scientific understanding of dosage, efficacy, mechanisms of action, and safety. Similar reliance on traditional practices has been reported across Nigeria and other African countries, particularly where access to formal veterinary services is limited (Uwagie-Ero *et al.*, 2017; McGaw & Abdalla, 2020; Hankiso *et al.*, 2024; Wendimu *et al.*, 2024). The frequent use of *Azadirachta indica*, *Khaya senegalensis*, *Vernonia amygdalina*, and *Terminalia avicennioides* is consistent with previous reports of their ethnoveterinary applications and potential effectiveness against gastrointestinal helminths and other livestock diseases (Fajimi & Taiwo, 2005; Saganuwan, 2017). Furthermore, identifying bioactive compounds, including phytol,  $\beta$ -sitosterol, linoleic acid, oleic acid, and hexadecanoic acid, provides a phytochemical basis for their traditional use and highlights their potential as candidates for further anthelmintic evaluation (Matté *et al.*, 2023; Salim *et al.*, 2023).

Despite this knowledge, dosage practices were largely

unstandardized and based on animal age, size, and previous experience. Differences in plant species, harvesting conditions, and preparation methods can alter bioactive constituent concentrations and therapeutic efficacy (Jato *et al.*, 2022; Mhlongo *et al.*, 2024; Géorcelin *et al.*, 2026). Although most respondents considered herbal anthelmintics safe, with only a few reporting mild effects such as reduced appetite and weakness, traditional use does not necessarily guarantee safety. Toxicity may vary according to plant species, dosage, preparation, and contamination, emphasizing the need for standardization and rigorous assessment of herbal medicines for quality, safety, and efficacy (WHO, 2013; Ekor, 2014).

Education level and years of trading experience were significantly associated with herbal anthelmintic use, suggesting that both formal education and accumulated practical experience influence ethnoveterinary practices. This aligns with previous studies linking educational attainment and livestock management experience to knowledge of and use of medicinal plants (Mafimisebi *et al.*, 2012; Mhlongo *et al.*, 2024). Conversely, age was not significantly associated with herbal anthelmintic use, suggesting that ethnoveterinary knowledge is transmitted across generations through family traditions, apprenticeship, and community interactions rather than being restricted to older traders (Eiki *et al.*,

2021; Ndou *et al.*, 2023).

Generally, the moderate to high knowledge levels observed indicate substantial indigenous knowledge acquired through practical experience and intergenerational transmission. Nevertheless, the persistence of moderate knowledge among a considerable proportion of respondents highlights gaps in scientific understanding and the limited pharmacological and toxicological evaluation of many medicinal plants. Systematic documentation, scientific validation, safety assessment, dosage standardization, and integration of indigenous knowledge with evidence-based veterinary medicine are therefore important to promote the safe and effective use of herbal anthelmintics and support sustainable livestock production (Silva *et al.*, 2024; Aremu *et al.*, 2026).

### Commonly Used Herbal Plants

The study demonstrated that livestock traders in Gusau possess substantial knowledge of medicinal plants used as herbal anthelmintics. *Azadirachta indica* was the most widely recognized (94%), followed by *Moringa oleifera* (91%) and *Acacia nilotica* (90%), alongside *Allium sativum*, *Carica papaya*, *Vernonia amygdalina*, *Zingiber officinale*, *Adansonia digitata*, and *Cucurbita* species. The widespread recognition of these plants reflects their long-standing integration into local ethnoveterinary practices. The prominence of *A. indica* agrees with recent studies highlighting neem as an accessible, affordable, and broad-spectrum antiparasitic plant (Hankiso *et al.*, 2024; Wendimu *et al.*, 2024). Its limonoids, azadirachtin, nimbins, and related compounds have demonstrated ovicidal, larvicidal, and antiparasitic activities against gastrointestinal helminths (Saleem *et al.*, 2021). Similarly, the high familiarity with *M. oleifera* reflects its growing ethnoveterinary importance, supported by flavonoids, phenolics, saponins, and vitamins that contribute to antioxidant, immunomodulatory, antimicrobial, and antiparasitic effects (Leone *et al.*, 2022; Wendimu *et al.*, 2024). *Acacia nilotica*, ranked third in familiarity, is widely used in ethnoveterinary medicine, with its anthelmintic effects largely attributed to condensed tannins that inhibit parasite feeding, egg hatching, larval development, and fecundity. Tannin-rich species such as *Acacia* spp. are therefore considered useful for sustainable control of gastrointestinal nematodes in ruminants (Hoste *et al.*, 2022). Similarly, *A. sativum* and *C. papaya* are important ethnoveterinary plants; garlic's allicin and papaya's benzyl isothiocyanate, carpaine, and papain possess antimicrobial and antiparasitic properties, with papaya preparations shown to reduce parasite burdens in small ruminants (Molefe *et al.*, 2023). Leaves were the predominant plant part used (96%), reflecting their accessibility, renewability, and high concentration of bioactive compounds, while their use supports sustainable harvesting and minimizes plant destruction (Hankiso *et al.*, 2024; Wendimu *et al.*, 2024).

### Patterns of Use, Dosage, and Administration

The study revealed that the preparation of herbal anthelmintics was largely based on traditional knowledge and practical experience. Powdering was the most common preparation method (87%), followed by crushing into paste (78%), decoction (71%), mixing with feed (67%), and infusion (51%). These methods facilitate storage, administration, and extraction of bioactive compounds, consistent with ethnoveterinary practices reported in Ethiopia and other African countries (Hankiso *et al.*, 2024; Wendimu *et al.*, 2024).

Oral drenching was the predominant route of administration (96%), followed by incorporation into feed (83%) and drinking water (64%). Dosage was mainly based on household measures such as cups (31%), handfuls (26%), and teaspoons (21%), rather than standardized units, reflecting the experiential nature of traditional veterinary practice (Hankiso *et al.*, 2024; Silva *et al.*, 2024). Most respondents administered remedies once or twice daily for three to five days, with treatment frequency and duration adjusted according to disease severity and perceived recovery (Wendimu *et al.*, 2024). While these practices support the continued use of medicinal plants, the lack of standardized dosing may affect efficacy, reproducibility, and safety.

Herbal remedies were used primarily for treating helminth infections (87%), while 61% of respondents reported using them for both prevention and treatment. This demonstrates that livestock traders perceive medicinal plants as both therapeutic and preventive health measures. Such applications may be supported by bioactive compounds, including tannins, flavonoids, saponins, and phenolics, which can interfere with parasite establishment, reduce worm fecundity, and enhance host immunity (Hoste *et al.*, 2022).

### Perceived Efficacy and Safety of Herbal Anthelmintics

Most respondents perceived herbal anthelmintics as effective, with 56% rating them moderately effective and 30% very effective. Only 9% considered them slightly effective and 5% ineffective. These favorable perceptions may explain the continued use of herbal remedies despite the availability of synthetic anthelmintics. Experimental evidence supports the anthelmintic potential of medicinal plants, with phytochemicals such as tannins, flavonoids, alkaloids, saponins, terpenoids, and phenolics reported to interfere with parasite metabolism, inhibit egg hatching, suppress larval development, and reduce adult worm burdens (Hoste *et al.*, 2022). The GC-MS findings of the present study, which identified compounds including phytol,  $\beta$ -sitosterol, linoleic acid, oleic acid, hexadecanoic acid, and squalene, further support the perceived antiparasitic potential of the investigated plants.

Reported improvements, including weight gain, increased appetite, better growth, reduced diarrhoea, and worm expulsion, were consistent with effective parasite control, as gastrointestinal helminths negatively affect nutrient absorption, feed utilization, and growth performance (Quadros & Burke, 2024). However, worm infection recurrence in 41% of respondents suggests limitations in achieving complete or sustained parasite control. Reinfection, inconsistent dosage, variation in phytochemical composition, and differences in preparation and extraction methods may contribute to treatment failure, as previously reported (Wendimu *et al.*, 2024). Regarding safety, 70% of respondents recognized that excessive dosing could cause adverse effects, although only 26% had observed reactions, mainly diarrhoea, temporary weakness, and reduced appetite. Mortality was rarely reported. These findings align with evidence that medicinal plants are generally safe at appropriate doses, while underscoring the need for further toxicological evaluation (Hankiso *et al.*, 2024; Wendimu *et al.*, 2024).

Confidence in herbal remedies was also high, with 46% considering them equally effective and 36% more effective than conventional veterinary drugs. Affordability, accessibility, and local availability of medicinal plants may contribute to these perceptions,

particularly where conventional veterinary services are limited or costly (Silva *et al.*, 2024; Wendimu *et al.*, 2024). The high willingness to continue using (93%) and recommend (99%) herbal anthelmintics demonstrates strong community acceptance and supports the preservation of indigenous knowledge. Nevertheless, rigorous pharmacological, toxicological, and clinical studies are needed to establish their efficacy, safety, quality, and appropriate dosage before wider integration into sustainable livestock healthcare programmes.

### Qualitative Phytochemical Screening

#### GC-MS Analyses

GC-MS analysis revealed that *Azadirachta indica*, *Moringa oleifera*, and *Acacia* species contain diverse bioactive compounds, including phytol, palmitic acid, linoleic acid, oleic acid, squalene, and  $\beta$ -sitosterol. These shared constituents may act synergistically and could contribute to the plants' traditional use against gastrointestinal helminths. These compounds are also associated with the potential ethnoveterinary value of these plants (Bergman *et al.*, 2019; Hu *et al.*, 2021). *A. indica* showed the highest phytol content (18.56%), followed by hexadecanoic acid,  $\beta$ -sitosterol, and oleic acid. Phytol possesses antioxidant, antimicrobial, anti-inflammatory, and antiparasitic activities, mainly through membrane disruption, oxidative stress induction, and interference with parasite metabolism, which may contribute to the plant's anthelmintic efficacy (Santos *et al.*, 2013; Islam *et al.*, 2018; Saad *et al.*, 2020).  $\beta$ -sitosterol also exhibits immunomodulatory, anti-inflammatory, and antiparasitic effects, while oleic and palmitic acids have demonstrated antimicrobial and antiparasitic activities. The presence of vitamin E ( $\alpha$ -tocopherol) and squalene further suggests antioxidant potential, which may help protect host tissues from oxidative stress during parasitic infections (Islam *et al.*, 2018; Bergman *et al.*, 2019). *Moringa oleifera* was dominated by linoleic acid (16.82%), followed by phytol, oleic acid, and vitamin E. Linoleic acid and other unsaturated fatty acids possess antimicrobial and antiparasitic properties through membrane disruption and interference with energy metabolism (Desbois & Smith, 2010). This agrees with reports that *M. oleifera* is rich in fatty acids, tocopherols, phytosterols, and other bioactive compounds with antioxidant, anti-inflammatory, and immunomodulatory activities (Leone *et al.*, 2015; Vergara-Jimenez *et al.*, 2017; Falowo *et al.*, 2018).

*Acacia* species contained the highest proportion of hexadecanoic acid (palmitic acid; 17.23%), followed by  $\beta$ -sitosterol, phytol, and oleic acid. Palmitic acid may contribute to antimicrobial and antiparasitic activity by disrupting membranes and inhibiting microbial growth (Desbois & Smith, 2010). Caryophyllene,  $\beta$ -sitosterol, and phytol may further enhance the ethnoveterinary potential of *Acacia*. Overall, the therapeutic effects of the three plants likely stem from synergistic interactions among fatty acids, terpenoids, phytosterols, and phenolics, which may promote membrane disruption, oxidative damage, enzyme inhibition, and immune modulation, thereby supporting antiparasitic activity (Wink, 2012; Salehi *et al.*, 2019).

#### Conclusion

This study showed that livestock traders in Gusau Market, Zamfara State, widely recognize and use herbal anthelmintics, with *Azadirachta indica*, *Moringa oleifera*, and *Acacia* species as the

most commonly used medicinal plants. Phytochemical screening and GC-MS analyses confirmed bioactive compounds associated with anthelmintic activity, providing scientific support for their traditional use. Although herbal remedies were generally perceived as effective, affordable, and safe, the absence of standardized dosage remains a major challenge. These findings highlight the importance of ethnoveterinary medicine in livestock health management and emphasize the need for further scientific validation, dosage standardization, and integration of evidence-based herbal therapies into sustainable parasite control programmes.

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