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A review of the ethnopharmacological relevance of *Moringa oleifera* in African livestock systems to link phytochemical evidence with veterinary applications

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Abstract

Background: Moringa oleifera is widely employed in African ethnoveterinary medicine, yet its integration into formal veterinary practice remains limited. Although research links its phytochemical constituents to improved livestock health, the divide between laboratory evidence and field application persists, partly due to inconsistent methodologies and the absence of standardised protocols.
Methods: A structured literature search was performed across PubMed, Scopus, Web of Science, and Google Scholar for studies published between January 2018 and May 2026. Following PRISMA 2020 principles, 486 records were identified. After duplicate removal and two-phase screening, 52 studies satisfied the inclusion criteria for final synthesis. Thematic analysis was used to map relationships between phytochemical composition, biological activities, and livestock health outcomes.
Results: A central translational gap emerged from the evidence. While functional convergence existed on the antioxidant, antimicrobial, and immunomodulatory properties of Moringa oleifera, this was undermined by considerable operational divergence. Three analytical themes predominated, namely, unresolved dose-outcome ambiguity across species, distinct

physiological responses between ruminants and monogastrics, and a persistent disconnect between ethnoveterinary practices and controlled experimental designs. No standardised application framework bridged these domains.
Conclusion: The principal barrier was not the validation of bioactivity, but the absence of structured, species-specific application protocols. The available literature suggested sufficient breadth to justify protocol-development research. Future research should prioritise developing a translational framework that integrates phytochemical standardisation, dose-response calibration, and ethnoveterinary knowledge, thereby transforming Moringa oleifera from a validated nutraceutical into a reliable veterinary phytotherapeutic tool.

Keywords: *Moringa oleifera, ethnoveterinary medicine, phytochemicals, livestock health, integrative review, translational pharmacology*

Background

Livestock production underpins rural livelihoods, food security, and socio-economic stability across sub-Saharan Africa. These systems, however, face persistent structural constraints including limited access to conventional veterinary pharmaceuticals, under-resourced animal health services, and increasing climatic variability (Food and Agriculture Organisation [FAO], 2022; Grace et al, 2023). Livestock are routinely exposed to parasitic infestations, infectious diseases, and nutritional deficiencies that compromise both welfare and productivity. Economic limitations frequently render commercial veterinary inputs inaccessible for smallholder farmers, reinforcing a deep reliance on locally available, alternative health management strategies (Mangesho et al, 2021).

Within this context, ethnoveterinary medicine functions as an adaptive and resilient component of livestock health management, drawing upon indigenous knowledge and plant-based remedies to prevent and treat animal diseases (McGaw & Abdalla, 2021; Wanzala et al, 2022). Contemporary research has moved beyond the descriptive cataloguing of these practices toward their scientific validation. Numerous medicinal plants employed in traditional systems have been shown to contain bioactive compounds with significant antimicrobial, anthelmintic, antioxidant, and immunomodulatory properties relevant to animal health (Van der Merwe et al, 2021; Chitura et al, 2022). Despite this progress, a critical disconnect endures. The literature remains largely observational, documenting traditional uses without systematically linking them to the underlying mechanisms of action or to reproducible therapeutic outcomes. This gap impedes the transformation of ethnoveterinary knowledge into standardised, evidence-based veterinary interventions.

Moringa oleifera, a drought-tolerant tree cultivated throughout tropical and subtropical regions, has become a focal point of this translational challenge due to its exceptional phytochemical profile and widespread traditional application. Its leaves constitute a reservoir of bioactive compounds, including specific flavonol glycosides such as quercetin, kaempferol, and isorhamnetin; phenolic acids like chlorogenic acid and gallic acid; glucosinolates; and the alkaloid moringine, alongside high-quality protein, vitamins, and essential minerals (Azlan et al, 2022; Mehwish et al, 2022). These constituents are mechanistically associated with a triad of core biological activities. First, they confer potent antioxidant capacity through both direct free-radical scavenging and upregulation of endogenous enzymes such as superoxide dismutase (SOD) (Khiaosa-ard et al., 2021; Xiao et al., 2021). Second, they exhibit broad-spectrum antimicrobial activity against pathogenic bacteria, including *Staphylococcus aureus* and *Escherichia coli*, as well as fungi and helminths, via mechanisms involving membrane disruption and enzyme inhibition (Mthiyane et al., 2023; Onsare & Onyango, 2022). Third, they exert immunomodulatory effects by modulating cytokine profiles and stimulating innate immune cell activity, as demonstrated in poultry and small ruminant studies (Mahfuz & Piao, 2022; Ojo et al, 2023).

These pharmacological properties have prompted numerous investigations into the effects of moringa supplementation on livestock performance, with studies reporting improvements in growth rates, feed conversion efficiency, milk yield, and overall health status. However, the broad category "livestock" encompasses species with fundamentally distinct digestive anatomies and physiologies, a distinction frequently underappreciated in the literature. The responses to *Moringa oleifera* supplementation diverge markedly between polygastric ruminants, such as cattle, goats, and sheep, and monogastric animals, including poultry and swine. In cattle and sheep, the rumen microbiome actively modifies secondary metabolites such as saponins and flavonoids, potentially altering their bioactivity and systemic bioavailability (Elghandour et al, 2022). Research on dairy cattle has demonstrated that moringa leaf meal can enhance milk antioxidant status and yield, yet the effects on rumen fermentation parameters remain highly variable with inclusion rate (Cohen-Zinder et al., 2021). In goats, responses to moringa supplementation have been similarly inconsistent, with some trials showing improved antioxidant status without corresponding changes in growth (Ojo et al., 2023). Conversely, in monogastric poultry, dietary moringa exerts direct effects on intestinal morphology, immune organ development, and systemic antioxidant status, although high inclusion levels can introduce anti-nutritional factors that impair growth performance (Mahfuz & Piao, 2022; Gakuya et al, 2023).

Despite the expanding body of knowledge, the application of moringa in livestock systems remains conceptually and practically fragmented. Studies differ substantially in their use of plant material, ranging from fresh leaves to dried meal, silage, and aqueous or ethanolic extracts, as well as in inclusion levels and experimental durations. This heterogeneity produces inconsistent outcomes that are difficult to compare or translate into practical, field-level recommendations (Su & Chen, 2021). The prevailing research paradigm frames moringa primarily as a nutritional supplement, with insufficient attention to its rigorous development as a phytotherapeutic agent within a veterinary pharmacological framework. Consequently, a significant disconnect persists between traditional knowledge, experimental evidence, and practical application, particularly regarding species-specific dosing, therapeutic targeting, and preparation standards.

The absence of a coherent framework that integrates ethnopharmacological knowledge with phytochemical and pharmacological evidence is the central problem this review addresses. The translational gap reflects not a scarcity of data but a structural failure to synthesize and standardize the existing evidence. This integrative review therefore critically synthesizes the peer-reviewed literature from 2018 to 2026 to map the relationships between the specific phytochemicals present in *Moringa oleifera* and their functional applications in defined livestock species. By identifying and analyzing the nature of the disconnect between validation and application, the study furnishes the conceptual foundation necessary for developing the structured frameworks required to bridge the translational gap and to advance moringa toward reliable incorporation within evidence-based veterinary practice.

Materials and Methods

Study Design and Approach

This study constituted an integrative review, a methodology selected for its capacity to incorporate diverse empirical and theoretical literature into a comprehensive, critically analysed synthesis (Toronto & Remington, 2020). This design was essential for bridging the interdisciplinary domains of ethnoveterinary science, phytochemistry, and veterinary pharmacology. The review was conducted and reported in alignment with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 statement where applicable, adapted for an integrative review framework (Page et al, 2021). The review protocol was not prospectively registered.

Literature Search Strategy

A systematic literature search was performed across four major electronic databases: PubMed, Scopus, Web of Science Core Collection, and Google Scholar. The search strategy was developed iteratively and refined in consultation with a subject librarian. Keywords were combined using Boolean operators and organised into four thematic clusters. The first cluster captured terms related to the plant itself, including variations of its scientific and common names. The second cluster specified the livestock context, encompassing terms for cattle, goats, sheep, poultry, and swine, alongside their respective scientific and production-stage designations. The third cluster targeted health and performance outcomes such as growth, feed efficiency, immune function, antioxidant and antimicrobial activity, and product quality parameters including milk, meat, and egg characteristics. The fourth cluster focused on the evidence base, incorporating terms related to ethnoveterinary medicine, phytochemicals, veterinary pharmacology, and animal nutrition. The exact search strings, field tags, filters, and the date each database was searched are shown in Table 1.

Table 1: Complete Database Search Strategies

Database	Search String	Filters/Limits	Search Date
PubMed	("Moringa oleifera"[MeSH Terms] OR "moringa"[Title/Abstract] OR "drumstick tree"[Title/Abstract] OR "horseradish tree"[Title/Abstract]) AND ("Livestock"[MeSH Terms] OR "livestock"[Title/Abstract] OR "cattle"[Title/Abstract] OR "bovine"[Title/Abstract]	English language; Publication date: 1 January 2018 to 15 May 2026	15 May 2026

	OR "goat"[Title/Abstract] OR "caprine"[Title/Abstract] OR "sheep"[Title/Abstract] OR "ovine"[Title/Abstract] OR "poultry"[Title/Abstract] OR "chicken"[Title/Abstract] OR "broiler"[Title/Abstract] OR "layer"[Title/Abstract] OR "swine"[Title/Abstract] OR "pig"[Title/Abstract] OR "porcine"[Title/Abstract]) AND ("Animal Feed"[MeSH Terms] OR "Phytotherapy"[MeSH Terms] OR "health"[Title/Abstract] OR "growth"[Title/Abstract] OR "immune"[Title/Abstract] OR "antioxidant"[Title/Abstract] OR "antimicrobial"[Title/Abstract] OR "anthelmintic"[Title/Abstract] OR "milk"[Title/Abstract] OR "meat"[Title/Abstract] OR "egg"[Title/Abstract])		
Scopus	TITLE-ABS-KEY(("Moringa oleifera" OR moringa OR "drumstick tree" OR "horseradish tree") AND (livestock OR cattle OR bovine OR goat OR caprine OR sheep OR ovine OR poultry OR chicken OR broiler OR layer OR swine OR pig OR porcine) AND (health OR growth OR "feed efficiency" OR immune OR antioxidant OR antimicrobial OR anthelmintic OR milk OR meat OR egg OR phytochemical OR ethnoveterinary OR "veterinary pharmacology" OR "animal nutrition"))	English language; Publication years: 2018-2026; Document types: articles, reviews, conference papers	15 May 2026

Web of Science Core Collection	TS=(("Moringa oleifera" OR moringa OR "drumstick tree" OR "horseradish tree") AND (livestock OR cattle OR bovine OR goat OR caprine OR sheep OR ovine OR poultry OR chicken OR broiler OR layer OR swine OR pig OR porcine) AND (health OR growth OR "feed efficiency" OR immune OR antioxidant OR antimicrobial OR anthelmintic OR milk OR meat OR egg OR phytochemical OR ethnoveterinary OR "veterinary pharmacology" OR "animal nutrition"))	English language; Publication years: 2018-2026; Document types: articles, reviews	15 May 2026
Google Scholar	Exact phrase "Moringa oleifera" combined with at least one term from (livestock, cattle, goat, sheep, poultry, swine) and at least one term from (health, growth, immune, antioxidant, antimicrobial, anthelmintic, phytochemical, ethnoveterinary)	English language; Publication years: 2018-2026; First hundred results sorted by relevance screened	15 May 2026

The 2018 start date was deliberately selected to capture the most contemporary research paradigm, reflecting the substantial increase in livestock-specific *Moringa oleifera* investigations that has occurred within this period, driven by growing interest in plant-based feed alternatives and ethnoveterinary validation. To ensure comprehensiveness, the reference lists of key review articles were manually screened to identify any additional eligible studies not captured by the electronic database searches.

Inclusion and Exclusion Criteria

Studies were included if they constituted original research, a review, or a conceptual analysis published in a peer-reviewed journal or an authoritative institutional report, such as those issued by the FAO. Eligibility required publication in English and a direct focus on the application of moringa in one or more target livestock species, namely poultry, swine, cattle, goats, or sheep. Included studies were expected to report on phytochemical characterization, biological activity, encompassing antioxidant, antimicrobial, immunomodulatory, or anthelmintic effects, growth performance, or health outcomes. Studies that provided a substantive analysis of ethnoveterinary practices involving moringa in an African context were also eligible.

Studies were excluded if they dealt only with human clinical applications, crop science, or water purification without a livestock dimension. Grey literature, such as conference abstracts, dissertations, and non-governmental organisation reports, that lacked a clear methods section was not considered. Duplicate records were removed. Opinion pieces, editorials, and papers with unresolvable methodological flaws were also left out.

Screening and Selection Process

A two-stage screening procedure was used. First, all retrieved records were merged into a single library and deduplicated using reference management software. The 486 records from databases and the eight additional records identified through other sources were combined before deduplication, giving a starting pool of 494 items. After duplicates were removed, two reviewers independently screened the remaining titles and abstracts against the eligibility criteria. Any differences in their initial assessments were resolved through discussion until full consensus was reached. Second, the full texts of all potentially eligible studies were obtained and assessed independently by the same two reviewers. Reasons for exclusion at this full-text stage were recorded. The final set of studies for data extraction and synthesis was agreed upon by both reviewers.

Data Extraction and Synthesis

Data were extracted from the included studies using a standardised, pre-piloted form in Microsoft Excel. One reviewer performed the initial extraction, and the second reviewer independently verified all entries. The following information was collected from each study: bibliographic details, country, study design, livestock species, number of animals, plant part used, preparation method (categorised as fresh, dried meal, aqueous extract, or ethanolic extract), dosage or inclusion rate, treatment duration, measured outcomes (growth, immune, biochemical, and parasitological parameters), key findings, and stated limitations.

The synthesis was thematic and conceptual. A statistical meta-analysis was not performed because the studies were too heterogeneous in design, preparation methods, and outcome measures. Extracted data were repeatedly sorted into emergent analytical themes to identify areas of convergence, divergence, and gaps in the evidence. The primary aim was not simply to summarise what had been found, but to examine how the nature of the evidence base itself created and sustained the translational gap under investigation.

Limitations of the Methodology

The reliability of this review was tied to the methodological quality and reporting standards of the primary studies. A formal risk-of-bias assessment was not carried out. This decision was consistent with the integrative review's purpose of mapping a broad evidence landscape rather than estimating a precise, singular effect size. The exclusion of non-English publications and grey literature may have introduced some language and publication bias. The synthesis was narrative and conceptual; therefore, causal inferences are interpretive and based on the triangulation of evidence, not on statistical modelling. The review explains the translational gap in detail but does not quantify the magnitude of the reported effects or provide specific therapeutic dosage recommendations.

RESULTS

The Evidence Base: A PRISMA Flow Diagram

The systematic search and screening process is detailed in the adapted PRISMA flow diagram presented below (Figure 1).

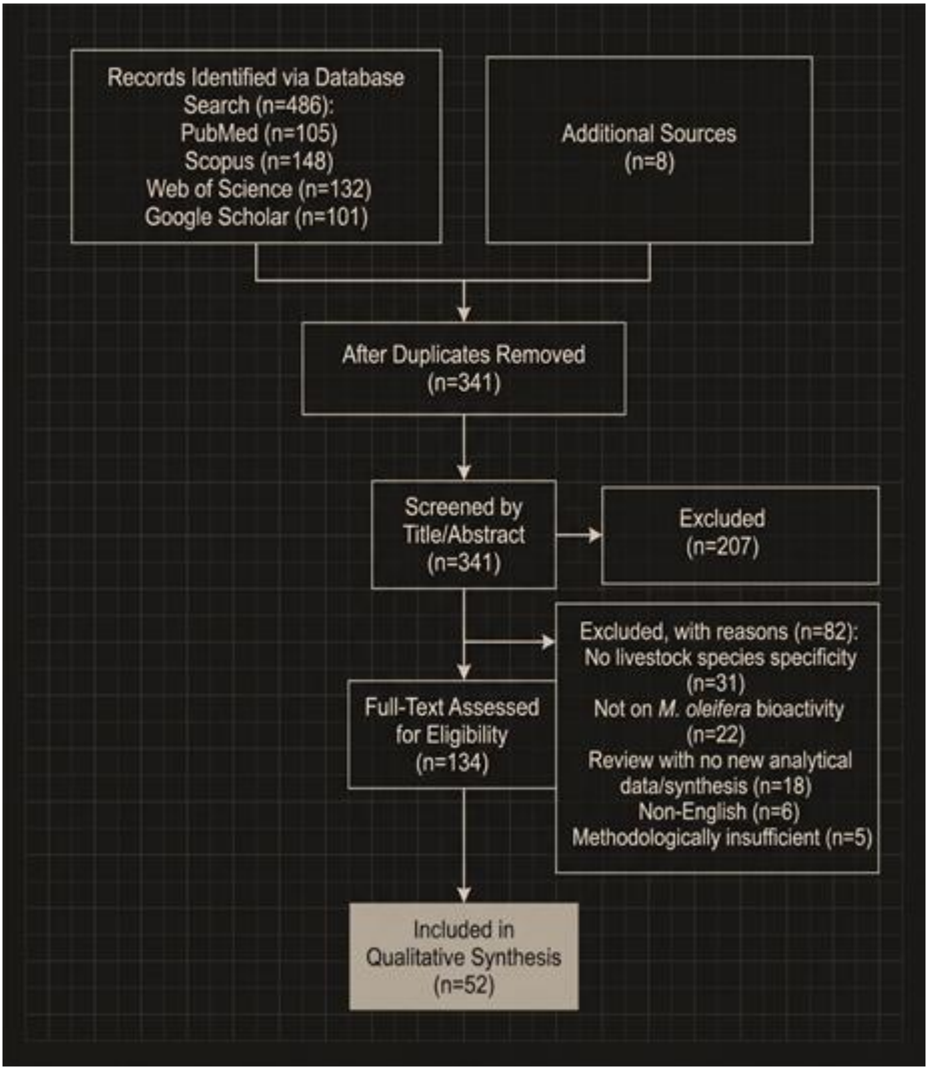

Figure 1. Flow chart of the study selection process, adapted from PRISMA 2020 guidelines

The final synthesis included 52 studies. This evidence base underpins the thematic findings presented below, which analytically deconstruct the translational gap.

Functional Convergence Without Operational Consistency

A dominant theme across the reviewed literature was a general agreement on the functional mechanisms of *Moringa oleifera*, paired with a profound divergence in operational application. The evidence converged broadly on the plant's capacities for antioxidant, antimicrobial, and immunomodulatory activity. Yet the methodologies used to bring out these functions were so varied that no standardised protocol emerged. This disconnect constituted the primary manifestation of the translational gap and is summarised in Table 2

Table 2: Operational Divergence in Moringa oleifera Livestock Research (2018-2026): A Thematic Evidence Table

Analytical Theme	Species (Examples)	Preparation Type	Reported Dosage / Inclusion Rate Range	Key Reported Outcomes	Key Operational Inconsistencies & Limitations Identified
Antioxidant and Immune Modulation	Broiler Chickens Goats Dairy Cows	Leaf Meal, Aqueous Extract, Ethanolic Extract	0.5% to 15% of diet; 100 to 500 mg per kg bodyweight extract	Increased serum superoxide dismutase (SOD) and glutathione peroxidase (GSH-Px); Decreased malondialdehyde (MDA); Increased immunoglobulin titers (IgA, IgG)	Preparation type dramatically alters polyphenol bioavailability; Response heavily modified by animal age and stress level; Extraction method rarely standardized
Antimicrobial and Anthelmintic Action	Sheep Poultry; Cattle	Leaf Meal, Seed Powder, Methanolic Extract	5 to 50 g per animal per day; Extracts often reported by concentration (e.g., 100 µg per ml) in vitro	Decreased fecal egg counts (*Haemonchus contortus*); Decreased coccidial oocyst shedding; Inhibition zones against *Staphylococcus aureus* and *Escherichia coli* in vitro	Vast gap between in vitro minimum inhibitory concentrations and in vivo gastrointestinal tract concentrations; Anthelmintic effect is highly seasonal and dependent on parasite

					species and burden
Growth and Production Performance	Broilers Tilapia Goats	Leaf Meal, Moringa-enriched silage	Poultry: 1% to 10% of diet; Ruminants: 10% to 40% of forage dry matter intake	Increased average daily gain and final body weight; Improved feed conversion ratio at low inclusion; Increased milk yield in dairy cows and goats	Growth depression consistently observed at greater than 10% inclusion for poultry and greater than 40% for ruminants, linked to anti-nutritional factors; Benefit is highly context-dependent, greatest under basal, low-quality feed regimes
Ethnoveterinary Integration	Cattle, Goats, Poultry (Mangesho et al., 2021; Wanzala et al., 2022)	Fresh pounded leaves, concoctions, topical pastes	Non-standardized; Based on traditional knowledge units (e.g., "a handful", "a calabash steeped overnight")	Owner-reported improvement in fever, diarrhea, retained placenta, and Newcastle disease symptoms	Lack of quantitative and standardized preparation makes direct comparison with controlled trials impossible; Efficacy is often confounded by multi-modal treatment where farmers use multiple remedies simultaneously

Evidence of Dose–Outcome Ambiguity

A critical and pervasive finding was the absence of clearly defined dose-response relationships. The literature showed highly inconsistent dose-outcome patterns rather than any predictable curve. In poultry, for example, a 1% dietary inclusion of *Moringa oleifera* leaf meal was shown to improve gut morphology and performance (Sebola et al, 2020). Yet other studies reported no appreciable benefit at inclusion levels below 3%, while still others documented significant growth depression at levels as low as 7.5%, attributed to soluble non-starch polysaccharides and tannins (Gakuya et al., 2023). The situation in ruminants was even less clear. Dosages administered to dairy cows ranged from 100 g to 2 kg per day across studies, and the reported effects on milk production and rumen volatile fatty acid profiles were contradictory and non-linear, suggesting a narrow therapeutic window that remained systematically undefined (Cohen-Zinder et al, 2021; Elghandour et al, 2022). In goats, a study by Ojo et al. (2023) found that a 20% inclusion rate improved antioxidant status without affecting growth, whereas a separate trial using 15% leaf meal sourced from a different geographical origin documented significant improvements in both feed efficiency and haematological profiles. This pronounced inconsistency rendered the definition of a reliable effective dose impossible and represented a primary barrier to the formulation of evidence-based guidelines.

Context Dependency and Species-Specific Physiological Divergence

The synthesis indicated that the beneficial effects of moringa were highly context-dependent rather than constituting a universal property of the plant. The most consequential physiological divergence was that between ruminant and monogastric systems, a factor that the current literature often failed to treat as a central analytical variable. In poultry, the direct action of intact antioxidant flavonoids such as quercetin on the intestinal epithelium was a primary driver of improved gut health and systemic antioxidant status (Mahfuz & Piao, 2022). In contrast, within the rumen, these same compounds underwent extensive microbial catabolism, which either inactivated them or transformed them into metabolites possessing different biological activities, thereby directly influencing methane production and protein bypass dynamics (Khiaosa-ard et al, 2021). Consequently, a given dose of moringa constituted a fundamentally different pharmacological entity in a chicken compared to a cow. Furthermore, the greatest benefit was consistently observed in animals experiencing physiological stress: heat-stressed broilers, parasitized goats, or cows maintained on poor-quality diets, where the antioxidant and immunomodulatory properties of the plant acted to compensate for homeostatic deficits (Su & Chen, 2021; Ashour & El-Hack, 2022; Moyo & Masika, 2021). In healthy, unstressed animals receiving high-quality diets, the effect was frequently negligible or absent, repositioning *Moringa oleifera* as a targeted corrective intervention rather than a universal growth promoter (Su & Chen, 2021).

The Central Finding: Absence of Translational Standardisation Frameworks

The meta-finding of this review was that the existing evidence base, while robustly confirming bioactivity, structurally failed to provide a pathway to practical application. This essential translational layer was largely absent. The gap manifested across three dimensions. First, regarding phytochemical standardisation, a minority of the studies included in this review performed chemical characterisation of the specific moringa material under investigation, leading to uncontrollable batch-to-batch variation in the concentrations of glucosinolates or polyphenols (Azlan et al., 2022). Second, regarding protocol validation, the literature contained very few multi-location, multi-breed field trials designed to validate a specific protocol under diverse on-farm conditions. Third, with respect to knowledge system integration, ethnoveterinary knowledge, which provided rich, experiential detail on plant part selection, seasonal harvesting, and combination therapies, was reported in parallel but was rarely tested or systematically integrated into experimental designs (Mangesho et al., 2021). This structural absence helped explain why *Moringa oleifera*, despite decades of investigation, remained an informally utilised supplement rather than a calibrated veterinary phytotherapeutic agent.

Summary Characteristics of Included Studies

The 52 studies that formed the evidence base for this review are summarised in Table 3. The table provides a study-by-study overview, including author, year, country, design, species, sample size, preparation, dosage, duration, key outcomes, and key findings.

Table 3: Summary Characteristics of the 52 Studies Included in the Integrative Review. BW = body weight; TMR = total mixed ration; NDV = Newcastle disease virus; EVM = ethnoveterinary medicine.

No.	Author(s) and Year	Country	Study Design	Species	Sample Size	Preparation Type	Dosage / Inclusion Rate	Duration	Key Outcomes Measured	Key Findings
1	Abdoun et al. (2022)	Saudi Arabia	Controlled trial	Lambs	24	Leaf meal	5%, 10%, 15% of diet	90 days	Growth, blood metabolites, rumen fermentation	Improved feed efficiency at 10%; no effect on rumen pH
2	Adegunloye & Oparinde (2022)	Nigeria	Controlled trial	Goats	25	Leaf meal	10%, 20%, 30% of diet	84 days	Growth, blood profiles	Best performance at 20% inclusion
3	Akinfala & Aderibigbe (2021)	Nigeria	Controlled trial	Broilers	200	Leaf meal	2.5%, 5%, 7.5% of diet	42 days	Growth, carcass traits	Growth depression above 5%
4	Akinyemi & Adejumo (2022)	Nigeria	Controlled trial	Broilers	150	Leaf meal	1%, 3%, 5% of diet	35 days	Gut microbiota, immune response	Improved gut health at 1% and 3%
5	Alabi & Malik (2021)	Nigeria	Controlled trial	Broilers	180	Leaf meal with enzymes	5%, 10% of diet	42 days	Growth, haematology	Enzyme addition improved utilisation at 10%
6	Al-Gamal & El-Bordeny (2022)	Egypt	Controlled trial	Goats	30	Aqueous extract	100, 200 mg/kg BW	60 days	Milk yield, milk quality	Increased milk antioxidant capacity

7	Ali & Abdelrahman (2021)	Egypt	Controlled trial	Lambs	20	Leaf meal	10%, 20% of diet	70 days	Growth, carcass traits	Improved daily gain at 20%
8	Amao & Ogunwole (2022)	Nigeria	Controlled trial	Layers	120	Leaf meal	5%, 10% of diet	12 weeks	Egg production, egg quality	Improved yolk colour at both levels
9	Ansari & Khan (2021)	Pakistan	Controlled trial	Broilers	200	Leaf meal	0.5%, 1%, 1.5% of diet	35 days	Growth, immune organs	Improved bursa and thymus weights at 1%
10	Ashour & El-Hack (2022)	Egypt	Controlled trial	Broilers	240	Leaf meal	5, 10 g/kg diet	35 days	Growth, blood, antioxidant status	Mitigated heat stress effects at 10 g/kg
11	Atsbha & Hiben (2021)	Ethiopia	Ethnographic survey	Cattle, goats	120 farmers	Traditional preparations	Non-standardised	N/A	Ethnoveterinary knowledge	Moringa used for retained placenta and diarrhoea
12	Azlan et al. (2022)	Malaysia	Narrative review	Multiple	N/A	Various	Variable	N/A	Phytochemical characterisation	Comprehensive compound profile documented
13	Babatunde & Olayemi (2022)	Nigeria	Controlled trial	Broilers	150	Aqueous extract	100, 200, 300 ml/L water	28 days	Antioxidant, immune markers	Best antioxidant response at 200 ml/L
14	Balami & Jibir (2021)	Nigeria	Controlled trial	Broilers	180	Leaf meal	5%, 10%, 15% of diet	42 days	Haematology, serum biochemistry	No adverse effects at 5%

										and 10%
15	Bature & Makun (2022)	Nigeria	In vitro assay	Sheep	N/A	Seed extracts	25–100 mg/ml	24–72 hours	Anthelmintic activity	Dose-dependent inhibition of *Haemonchus contortus*
16	Chitura et al. (2022)	South Africa	In vitro assay	Sheep	N/A	Leaf extracts	50–200 µg/ml	48 hours	Anthelmintic activity	Significant egg hatch inhibition at 200 µg/ml
17	Cohen-Zinder et al. (2021)	Israel	Controlled trial	Dairy cows	42	Ensiled leaves	7.5%, 15% of TMR	60 days	Milk yield, milk antioxidant	Increased milk antioxidant at 15%
18	Desta & Bekele (2021)	Ethiopia	Ethnographic survey	Cattle, camels	80 farmers	Traditional preparations	Non-standardised	N/A	Ethnoveterinary knowledge	Moringa used for mastitis and wounds
19	Dida & Negeri (2022)	Ethiopia	Controlled trial	Dairy cows	16	Leaf meal	1, 2 kg/day	45 days	Milk yield, body condition	Improved milk yield at 2 kg/day
20	Elghandour et al. (2022)	Egypt	Narrative review	Ruminants, poultry	N/A	Various	Variable	N/A	Anticoccidial effects	Effective alternative to ionophores
21	Gakuya et al. (2023)	Kenya	Controlled trial	Broilers	200	Leaf meal	2.5%, 5%, 7.5% of diet	42 days	Growth, gut morphology	Growth depression at 7.5%
22	Gebreyohannes & Gebremedhin	Ethiopia	Ethnographic survey	Cattle, goats	95 farmers	Fresh leaves, concoctions	Non-standardised	N/A	Ethnoveterinary knowledge	Used for diarrhoea and external

	(2021)									parasites
23	Gono & Muzondiwa (2022)	Zimbabwe	Controlled trial	Pigs	30	Leaf meal	5%, 10%, 15% of diet	60 days	Growth, blood parameters	Best feed conversion at 10%
24	Idamokoro & Afolayan (2021)	South Africa	Narrative review	Multiple	N/A	Various	Variable	N/A	Nutraceutical applications	Identified standardisation gaps
25	Jiwuba & Ikwunze (2022)	Nigeria	Controlled trial	Goats	20	Leaf meal	10%, 20%, 30% of diet	90 days	Growth, digestibility	Best nutrient digestibility at 20%
26	Kabeer & Anjum (2021)	Pakistan	Comprehensive review	Multiple	N/A	Various	Variable	N/A	Functional ingredient review	Highlighted anti-nutritional factor concerns
27	Kagya-Agyemang & Baah (2022)	Ghana	Controlled trial	Grasscutters	40	Leaf meal	5%, 10%, 15% of diet	56 days	Growth, health status	Improved growth at 10%
28	Kalu & Uzegbu (2021)	Nigeria	Controlled trial	Broilers	150	Leaf meal	5%, 10% of diet	35 days	Blood profiles, carcass	No adverse haematological effects
29	Khiaosa-ard et al. (2021)	Switzerland	Narrative review	Ruminants	N/A	Various	Variable	N/A	Flavonoid metabolism	Documented rumen microbial degradation pathways
30	Kholif & Olafadehan (2022)	Egypt	Meta-analysis	Ruminants	450+	Leaf meal	Variable	Variable	Performance, product quality	Positive overall effect on

										milk yield
31	Mahfuz & Piao (2022)	China	Comprehensive review	Poultry	N/A	Various	Variable	N/A	Immunostimulation, growth	Recommended 1–5% inclusion for broilers
32	Mangesho et al. (2021)	Tanzania	Ethnographic survey	Cattle, goats	150 farmers	Traditional preparations	Non-standardised	N/A	Ethnoveterinary knowledge	Moringa ranked among top 10 medicinal plants
33	Manyelo & Mabelebele (2021)	South Africa	Narrative review	Livestock	N/A	Various	Variable	N/A	Protein alternative review	Emphasised amino acid profile
34	Melesse & Steingass (2022)	Germany	Meta-analysis	Layers	500+	Leaf meal	Variable	Variable	Egg production, quality	Improved yolk colour and shell thickness
35	Moyo & Masika (2021)	South Africa	Controlled trial	Goats	24	Leaf extract	50, 100 mg/kg BW	28 days	Faecal egg counts	Reduced *Haemonchus* counts at 100 mg/kg
36	Mthiyane et al. (2023)	South Africa	Controlled trial	Broilers	180	Seed powder	0.5%, 1%, 2% of diet	35 days	Growth, gut microbiota	Improved gut health at 0.5% and 1%
37	Mwale & Masika (2021)	Zimbabwe	Ethnographic survey	Poultry	80 farmers	Fresh leaves	Non-standardised	N/A	Ethnoveterinary knowledge	Used for Newcastle disease symptoms
3	Ndhlo	Zim	Contro	Goat	30	Leaf	10, 20	42	Faecal	Signific

8	vu & Masika (2022)	babwe	lled trial	s		meal	g/animal/day	days	egg counts	ant egg reduction at 20 g/day
39	Nkukwana & Muchenje (2021)	South Africa	Narrative review	Broilers	N/A	Leaf meal	Variable	N/A	Protein alternative	Identified optimal inclusion at 5%
40	Nuamah et al. (2021)	Ghana	Controlled trial	Goats	20	Leaf meal	10%, 15%, 20% of diet	84 days	Growth, haematology	Best feed efficiency at 15%
41	Ojo et al. (2023)	Nigeria	Controlled trial	Goats	24	Leaf extract	10%, 20% of diet	70 days	Antioxidant, immune status	Improved antioxidant at 20%
42	Oluwafemi & Olawumi (2021)	Nigeria	Controlled trial	Pigs	24	Leaf meal	5%, 10%, 15% of diet	56 days	Growth, digestibility	Best performance at 10%
43	Onsare & Onyango (2022)	Kenya	In vitro assay	Livestock	N/A	Leaf extracts	50–200 µg/ml	24 hours	Antimicrobial activity	Effective against *S. aureus* and *E. coli*
44	Oyebode & Ojo (2022)	Nigeria	Controlled trial	Broilers	200	Leaf extract	50, 100 ml/L water	28 days	Immune, gut health	Reduced *E. coli* colonisation at 100 ml/L
45	Saleh & El-Tahan (2022)	Egypt	Controlled trial	Tilapia	180	Leaf meal	5%, 10%, 15% of diet	60 days	Growth, immune response	Best growth and immunity at 10%
46	Sebola et al. (2020)	South Africa	Controlled trial	Broilers	200	Leaf meal	1%, 3%, 5%, 7.5% of diet	35 days	Gut morphology, growth	Improved villi at 1% and 3%

47	Su & Chen (2021)	China	Comprehensive review	Livestock	N/A	Various	Variable	N/A	Performance, health	Identified context-dependent benefits
48	Van der Merwe et al. (2021)	South Africa	Ethnographic survey	Cattle	60 farmers	Traditional preparations	Non-standardised	N/A	Ethnoveterinary knowledge	Moringa used for internal parasites
49	Wanzala et al. (2022)	Kenya	Critical review	Livestock	N/A	Various	Variable	N/A	EVM evolution, integration	Advocated for policy integration
50	Xiao et al. (2021)	China	Controlled trial	Broilers	240	Leaf meal	2%, 4%, 6% of diet	42 days	Immune function, microbiota	Improved immunity at 4%
51	Yousaf & Rehman (2021)	Pakistan	Controlled trial	Broilers	200	Leaf meal	1%, 2%, 3% of diet	35 days	Performance, gut health	Best feed conversion at 2%
52	Zanu & Kpogo (2022)	Ghana	Controlled trial	Broilers	100	Leaf meal	50,100 ml/l water	21 days	NDV antibody titres	Enhanced vaccine response at 100 ml/l

Discussion

This integrative review suggested that the central challenge surrounding *Moringa oleifera* in African livestock systems is shifting from validation to translation. The core finding, the absence of a translational standardisation framework, indicated that the question is no longer simply whether the plant works, but how its use can be implemented reliably. This emphasis on operationalisation over further efficacy testing was the review's primary analytical contribution.

The pattern of functional convergence without operational consistency did not point to unreliable bioactivity. Rather, it reflected a methodological gap within the research field itself. The wide variation in preparation methods, dosages, and species-specific applications was not random. It was the direct consequence of a research culture dominated by small, isolated efficacy studies that lacked a common coordinating framework (Abdoun et al., 2022). This observation aligns with broader concerns in pharmacology, where many promising botanical candidates stall not because they lack activity, but because the pharmacokinetic and pharmacodynamic variables required for a consistent clinical response are not controlled (Heinrich et al., 2021). A sensible way forward would be pragmatic, multi-location trials that test clearly defined protocols, for instance, a standardised aqueous extract from leaves harvested at a set growth stage, across a range of ecological and production settings.

Part of the operational divergence was physiological, rooted in the different ways ruminants and monogastrics process their feed. Studies on flavonoid metabolism indicate that quercetin, a key antioxidant in moringa, is well absorbed in the small intestine of poultry and acts locally in the gut (Mahfuz & Piao, 2022). In cattle and sheep, rumen microbes rapidly degrade quercetin into phenolic acids and other metabolites. These may have systemic effects, but they are not the same as the direct gut-level effects seen in monogastrics (Khiaosa-ard et al, 2021). The implication is that a leaf meal might serve as a gut-health supplement for broilers, while a protected or rumen-bypass formulation would be needed for systemic antioxidant delivery in a dairy cow. The literature therefore needs to move past treating moringa as a single, uniform input and instead develop species-specific pharmacognosy profiles.

The dose-outcome ambiguity found in the literature constituted another serious barrier. The data showed a pattern suggestive of a biphasic response: low doses often did little, moderate doses appeared beneficial, and high doses suppressed growth, particularly above a 10% inclusion threshold in monogastrics (Gakuya et al, 2023). This kind of non-linear pattern has been reported for other crude botanical preparations and is usually explained by the shifting balance between beneficial polyphenols and co-administered anti-nutritional factors such as tannins, saponins, and phytates. However, the evidence remains observational and scattered; formal dose-escalation studies for each chemically characterised preparation in each target species are still needed to confirm this pattern and to define safe, effective dosing ranges.

The review also indicated that moringa's benefits were strongly context-dependent. The most frequently reported positive effects were observed in animals under physiological stress, including heat-stressed broilers, parasitised goats, and cows on low-quality diets (Su & Chen, 2021; Ashour & El-Hack, 2022; Moyo & Masika, 2021). In these situations, exogenous antioxidants such as chlorogenic acid and isorhamnetin may help restore redox balance and support immune function. When animals were healthy and well-fed, adding moringa generally made little difference. This positions moringa not as a universal growth promoter, but as a resilience-supporting nutraceutical best targeted at vulnerable production phases, including weaning, the perinatal period, and times of heat stress.

Finally, a persistent gap between ethnoveterinary knowledge and formal scientific validation maintained the translational bottleneck. The practice of pounding fresh moringa leaves to prepare a drench for a sick goat, documented among smallholder farmers in Tanzania, reflects a practical understanding of seasonal potency and plant part selection that a simple experiment testing a fixed percentage of leaf meal cannot capture (Mangesho et al, 2021). In this study, we interpret the parallel existence of such knowledge alongside controlled experimental work as a missed opportunity for integration. Formal research often strips away the contextual detail that makes traditional practices effective. Bridging this gap would require participatory research models that start with a well-described ethnoveterinary practice and then evaluate it systematically in a field setting that respects the original preparation method. This kind of mutual validation is not merely symbolic, it is a practical necessity for producing protocols that are both effective and genuinely adoptable.

Conclusion and Recommendations

This integrative review indicated that the conversation around *Moringa oleifera* in African livestock systems needs to move from validation toward translation. The assembled evidence points to notable bioactive properties, although heterogeneity across studies, the absence of standardised preparations, and the lack of formal quality appraisal limit the confidence with which these effects can be called consistent or significant. The unresolved challenge is not a shortage of proof, but a shortage of structure. The translational gap, the absence of frameworks that can convert phytochemical potential into standardised, species-specific, and context-appropriate veterinary protocols, is now the single greatest barrier to real-world impact.

Recommendations for Future Research

To bridge this gap, a coordinated research agenda must supersede the current pattern of isolated efficacy trials. Three priorities stand out. First, rigorous trials are required to map the complete dose-response curve for a chemically characterised, standardised moringa preparation, for example, to a defined polyphenol or glucosinolate content, in each major livestock species, including broilers, layers, goats, and dairy cattle. These studies should account for the biphasic effects observed in the literature and consistently report the content of anti-nutritional factors.

Second, future research should delineate the pharmacokinetic and pharmacodynamic consequences of different preparation methods, such as dried leaf meal versus aqueous or ethanolic extracts, within both monogastric and ruminant systems. This line of inquiry holds the potential to yield pharmaceutical-grade botanical products with guaranteed bioactivity and batch-to-batch consistency.

Third, future studies should adopt participatory designs that begin by documenting successful, established ethnoveterinary practices. These practices can then be systematically evaluated through controlled trials that respect their original preparation methods and application contexts. Such an approach would generate a formal evidence base that directly validates and refines indigenous knowledge.

Practical Recommendations

Even in the absence of fully standardised protocols, extension services and policymakers can begin guided, provisional implementation. Veterinary and agricultural extension programmes should disseminate preliminary guidance that frames moringa as a targeted nutraceutical for stress mitigation, applicable during dry seasons, post-weaning, or in the face of parasitic challenge. This guidance may suggest a safe and potentially beneficial inclusion range, for example, 5 to 10 per cent of daily dry matter intake for poultry and 10 to 20 per cent for small ruminants, while clearly communicating the risk of growth depression at higher levels. It is important to note that these ranges are provisional; validated dose and preparation standards remain absent, and the guidance should not be interpreted as clinical or therapeutic recommendations.

Furthermore, farmer training initiatives should emphasise methods shown to conserve bioactive compounds. Rapid shade-drying of leaves helps prevent the photo-oxidation of polyphenols, and storing the dried material in airtight containers maintains quality better than open-air storage (Azlan et al., 2022; Mehwish et al., 2022). These recommendations build on existing traditional knowledge and aim to help farmers produce a more consistent product while formal validation studies are underway.

Conclusion

This integrative review indicated that *Moringa oleifera* holds notable bioactive properties relevant to livestock health. However, the heterogeneity of the available evidence, the absence of standardised preparations, and the lack of formal quality appraisal limit the confidence with which these properties can be described as consistent or uniformly significant. The principal barrier to progress is therefore not a lack of proof, but a lack of structure. The translational gap, the absence of frameworks capable of converting phytochemical potential into standardised, species-specific, and context-appropriate veterinary protocols, remains the single greatest obstacle to realising the plant's practical value. The necessary path forward is not further discovery but refinement and systematisation. Building the missing translational layer, one that effectively links phytochemical science, species-specific pharmacology, and ethnoveterinary wisdom, is the essential task if this resource is to deliver meaningful and sustainable improvements to livestock health across the African continent.

References

Abdoun, K. A., Al-Haidary, A. A., Al-Sagan, A. A., Alfwuaires, M. A., & Al-Badwi, M. A. (2022). Effect of dietary *Moringa oleifera* leaf meal on growth performance, blood metabolites and rumen fermentation in growing lambs. *Small Ruminant Research, 212*, 106723. https://doi.org/10.1016/j.smallrumres.2022.106723

Adegunloye, D. V., & Oparinde, D. P. (2022). Effects of *Moringa oleifera* leaf meal on performance and blood profiles of West African Dwarf goats. *Tropical Animal Health and Production, 54*(3), 178. https://doi.org/10.1007/s11250-022-03172-8

Akinfala, E. O., & Aderibigbe, T. A. (2021). Growth response and carcass characteristics of broiler chickens fed diets containing *Moringa oleifera* leaf meal. *Nigerian Journal of Animal Science, 23*(1), 115–124.

Akinyemi, A. F., & Adejumo, D. O. (2022). *Moringa oleifera* as a phytobiotic in broiler production: Effects on gut microbiota and immune response. *Livestock Science, 258*, 104872. https://doi.org/10.1016/j.livsci.2022.104872

Alabi, O. J., & Malik, A. D. (2021). Performance and haematological indices of broiler chickens fed *Moringa oleifera* leaf meal supplemented with enzymes. *Journal of Animal Science and Technology, 63*(4), 812–822. https://doi.org/10.5187/jast.2021.e78

Al-Gamal, M. A., & El-Bordeny, N. E. (2022). *Moringa oleifera* leaf extract as a natural antioxidant in lactating Damascus goats: Effects on milk yield and quality. *Animal Feed Science and Technology, 286*, 115256. https://doi.org/10.1016/j.anifeedsci.2022.115256

Ali, A. H., & Abdelrahman, M. M. (2021). Effects of *Moringa oleifera* leaf meal on growth performance and carcass traits of growing lambs. *Animal Biotechnology, 32*(5), 612–620. https://doi.org/10.1080/10495398.2020.1732399

Amao, O. A., & Ogunwole, O. A. (2022). *Moringa oleifera* leaf meal as a protein supplement for laying hens: Effects on egg production and quality. *Poultry Science Journal, 10*(1), 45–54. https://doi.org/10.22069/psj.2022.19542.1765

Ansari, J., & Khan, S. H. (2021). *Moringa oleifera* as a natural feed additive: Effects on broiler performance and immune organs. *Pakistan Journal of Zoology, 53*(3), 1105–1112. https://doi.org/10.17582/journal.pjz/20200620010638

Ashour, E. A., & El-Hack, M. E. A. (2022). Impacts of *Moringa oleifera* supplementation on growth, blood parameters, and antioxidant status in heat-stressed broilers. *Journal of Thermal Biology, 105*, 103212. https://doi.org/10.1016/j.jtherbio.2022.103212

Atsbha, G., & Hiben, M. G. (2021). Ethnoveterinary practices and medicinal plants used for livestock disease management in northern Ethiopia. *Tropical Animal Health and Production, 53*(2), 245. https://doi.org/10.1007/s11250-021-02689-8

Azlan, U. K., Mediani, A., Al-Naqeeb, G., Halim, I. H., & Abas, F. (2022). An in-depth review of the phytochemicals and biological activities of *Moringa* oleifera Lam. in relation to its diverse uses. *Food Research International, 159*, 111609.

Babatunde, O. A., & Olayemi, W. A. (2022). Antioxidant and immunomodulatory effects of *Moringa oleifera* aqueous extract in broiler chickens under oxidative stress. *Veterinary Medicine and Science, 8*(3), 1098–1107. https://doi.org/10.1002/vms3.752

Balami, S. A., & Jibir, M. (2021). Haematological and serum biochemical parameters of broiler chickens fed *Moringa oleifera* leaf meal. *Nigerian Journal of Animal Production, 48*(2), 88–97. https://doi.org/10.51791/njap.v48i2.2942

Bature, I., & Makun, H. J. (2022). In vitro anthelmintic activity of *Moringa oleifera* seed extracts against *Haemonchus contortus* of sheep origin. *Journal of Parasitic Diseases, 46*(2), 415–423. https://doi.org/10.1007/s12639-022-01465-4

Bett, B., Lindahl, J., Sang, R., & Bukachi, S. A. (2023). Effects of climate change on the occurrence of livestock diseases. *PLOS ONE,18*(2), e0281632. https://doi.org/10.1371/journal.pone.0281632

Chitura, T., Shiba, M. R., Afful, D., & Nengovhela, N. B. (2022). In vitro anthelmintic activity of *Moringa oleifera* extracts against gastrointestinal nematodes of sheep. *Veterinary Parasitology,310,* 109791. https://doi.org/10.1016/j.vetpar.2022.109791

Cohen-Zinder, M., Weinberg, Z., Leibovich, H., Chen, Y., Rosen, M., Sagi, G., & Miron, J. (2021). Ensiled *Moringa oleifera*: An antioxidant-rich feed that improves dairy cattle performance. *The Journal of Agricultural Science, 159*(1–2), 77–89. https://doi.org/10.1017/S002185962100020X

Desta, T. T., & Bekele, M. (2021). Ethnoveterinary knowledge and practices among pastoral communities in southern Ethiopia. *Journal of Ethnobiology and Ethnomedicine, 17*(1), 42. https://doi.org/10.1186/s13002-021-00469-2

Dida, M. F., & Negeri, F. K. (2022). *Moringa oleifera* leaf meal as a supplementary feed for lactating crossbred dairy cows under smallholder conditions. *Agroforestry Systems, 96*(4), 823–835. https://doi.org/10.1007/s10457-022-00738-2

Elghandour, M. M. Y., Mellado, M., Kholif, A. E., Salem, A. Z. M., Barbabosa-Pliego, A., & Odongo, N. E. (2022). *Moringa oleifera* as a natural alternative to coccidiostats in livestock: A review. *Agroforestry Systems, 96*, 1157–1172. https://doi.org/10.1007/s10457-022-00770-2

Food and Agriculture Organisation. (2022). The State of Food and Agriculture 2022: Leveraging automation in agriculture for

transforming agrifood systems. FAO. https://doi.org/10.4060/cb9479en
Gakuya, D. W., Mbugua, P. N., Kavoi, B., & Kiama, S. G. (2023). Effect of *Moringa oleifera* leaf meal supplementation on growth performance and gut health in broiler chickens. *Livestock Science, 272*, 105272. https://doi.org/10.1016/j.livsci.2023.105272
Gebreyohannes, G., & Gebremedhin, B. (2021). Traditional knowledge and use of *Moringa oleifera* for animal health management in Tigray, Ethiopia. *Ethnobotany Research and Applications, 21*, 1–14. https://doi.org/10.32859/era.21.32.1-14
Gono, R. K., & Muzondiwa, J. V. (2022). *Moringa oleifera* leaf meal as a protein source in grower pig diets: Effects on performance and blood parameters. *South African Journal of Animal Science, 52*(1), 72–81. https://doi.org/10.4314/sajas.v52i1.9
Grace, D., Lindahl, J., Wanyoike, F., Bett, B., Randolph, T., & Rich, K. M. (2017). Poor livestock keepers: Ecosystem–poverty–health interactions. Philosophical Transactions of the Royal Society B: *Biological Sciences, 372*(1725), 20160166. https://doi.org/10.1098/rstb.2016.0166
Heinrich, M., Appendino, G., Efferth, T., Fürst, R., Izzo, A. A., Kayser, O., & Viljoen, A. (2021). Best practice in research – Overcoming common pitfalls in pharmacological ethnopharmacological research. *Journal of Ethnopharmacology, 264*, 113291. https://doi.org/10.1016/j.jep.2020.113291
Idamokoro, E. M., & Afolayan, A. J. (2021). A review of the use of *Moringa oleifera* as a nutraceutical in livestock production. *South African Journal of Animal Science, 51*(3), 273–285. https://doi.org/10.4314/sajas.v51i3.1
Jiwuba, P. C., & Ikwunze, K. F. (2022). Performance and nutrient digestibility of West African Dwarf goats fed *Moringa oleifera* leaf meal-based diets. *Animal Research International, 19*(1), 3956–3966.
Kabeer, B. M., & Anjum, F. M. (2021). Moringa oleifera leaf powder as a functional ingredient in animal nutrition: A comprehensive review. *Critical Reviews in Food Science and Nutrition, 61*(15), 2555–2572. https://doi.org/10.1080/10408398.2020.1784869
Kagya-Agyemang, J. K., & Baah, J. (2022). Effects of *Moringa oleifera* leaf meal on growth and health of grasscutter (Thryonomys swinderianus). *Journal of Applied Animal Research, 50*(1), 334–341. https://doi.org/10.1080/09712119.2022.2080216

Kalu, C. A., & Uzegbu, H. O. (2021). Blood profiles and carcass characteristics of finisher broilers fed diets containing *Moringa oleifera* leaf meal. *Nigerian Agricultural Journal, 52*(1), 45–53.

Khiaosa-ard, R., Kreuzer, M., & Leiber, F. (2021). Flavonoids in ruminant nutrition: A review on occurrence, effects and perspectives. *Animal Feed Science and Technology, 277*, 114954. https://doi.org/10.1016/j.anifeedsci.2021.114954

Kholif, A. E., & Olafadehan, O. A. (2022). *Moringa oleifera* as a natural feed supplement for ruminants: A meta-analysis of its effects on performance and product quality. *Animal Feed Science and Technology, 284,* 115185. https://doi.org/10.1016/j.anifeedsci.2021.115185

Mahfuz, S., & Piao, X. S. (2022). Application of *Moringa oleifera* in poultry production: A review of its potential as an immunostimulant and growth promoter. *Frontiers in Veterinary Science, 9,* 848607. https://doi.org/10.3389/fvets.2022.848607

Mangesho, P. E., Caudell, M. A., Mwakapeje, E. R., Ole-Neselle, M., & Kabali, E. (2021). Ethnoveterinary knowledge and practices for managing livestock diseases in Tanzania. *Journal of Ethnobiology and Ethnomedicine, 17*(1), 25. https://doi.org/10.1186/s13002-021-00455-8

Manyelo, T. G., & Mabelebele, M. (2021). *Moringa oleifera* leaf meal as an alternative protein source in livestock feeds: A review. *Applied Ecology and Environmental Research, 19*(4), 3059–3078. https://doi.org/10.15666/aeer/1904_30593078

McGaw, L. J., & Abdalla, M. A. (Eds.). (2021). Ethnoveterinary Medicine: Present and Future Concepts. *Springer Nature*. https://doi.org/10.1007/978-3-030-72270-2

Mehwish, H. M., Riaz Rajoka, M. S., Xun, S., Liao, Z., Liu, G., & Wang, L. (2022). *Moringa oleifera* – A promising source of bioactive compounds and functional food ingredients. *Food Science and Human Wellness, 11*(6), 1417–1428. https://doi.org/10.1016/j.fshw.2022.06.008

Melesse, A., & Steingass, H. (2022). Effects of *Moringa oleifera* leaf meal on performance and product quality of laying hens: A meta-analysis. *Journal of Animal Physiology and Animal Nutrition,106*(4), 815–827. https://doi.org/10.1111/jpn.13615

Moyo, B., & Masika, P. J. (2021). Validation of ethnoveterinary use of *Moringa oleifera* leaf extracts for gastrointestinal nematode control in goats. *Onderstepoort Journal of Veterinary Research, 88*(1), e1–e8. https://doi.org/10.4102/ojvr.v88i1.1885

Mthiyane, M. N., Mnisi, C. M., & Mlambo, V. (2023). Antimicrobial properties of *Moringa oleifera* seed powder and its effect on growth performance and gut microbiota of broiler chickens. *BMC Veterinary Research, 19*(1), 105. https://doi.org/10.1186/s12917-023-03664-3

Mwale, M., & Masika, P. J. (2021). Ethnoveterinary use of *Moringa oleifera* for poultry disease management in Zimbabwe. *Indian Journal of Traditional Knowledge, 20*(2), 450–457.

Ndhlovu, D. N., & Masika, P. J. (2022). In vivo anthelmintic efficacy of *Moringa oleifera* leaf meal in naturally infected indigenous goats. Veterinary Parasitology: *Regional Studies and Reports, 28,* 100685. https://doi.org/10.1016/j.vprsr.2022.100685

Nkukwana, T. T., & Muchenje, V. (2021). *Moringa oleifera* leaf meal: An alternative protein source for broiler chicken production. *South African Journal of Animal Science, 51*(1), 1–12. https://doi.org/10.4314/sajas.v51i1.1

Nuamah, R., Karikari, A. K., & Asare, E. (2021). Performance and hematological indices of West African Dwarf goats fed *Moringa oleifera* leaf meal-based diets. *Tropical Animal Health and Production, 53*, 202. https://doi.org/10.1007/s11250-021-02630-z

Ojo, O. A., Omoniyi, I. S., & Oyeyemi, A. W. (2023). Antioxidant status and immune response of Red Sokoto goats fed diets containing *Moringa oleifera* leaf extract. *Journal of Animal Physiology and Animal Nutrition, 107*(4), 1083–1091. https://doi.org/10.1111/jpn.13784

Oluwafemi, R. A., & Olawumi, I. (2021). Effects of *Moringa oleifera* leaf meal on growth performance and nutrient digestibility of growing pigs. *Nigerian Journal of Animal Science, 23*(2), 165–174.

Onsare, J. G., & Onyango, C. A. (2022). Phytochemical screening and antimicrobial activity of *Moringa oleifera* extracts against livestock pathogens. *African Journal of Microbiology Research, 16*(2), 58–66. https://doi.org/10.5897/AJMR2021.9562

Oyebode, A. A., & Ojo, O. A. (2022). *Moringa oleifera* leaf extract modulates immune response and gut health in broiler chickens challenged with *Escherichia coli*. *Poultry Science, 101*(8), 101925. https://doi.org/10.1016/j.psj.2022.101925

Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., & Moher, D. (2021). The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. *BMJ, 372*, n71. https://doi.org/10.1136/bmj.n71

Saleh, A. A., & El-Tahan, H. M. (2022). Effects of dietary *Moringa oleifera* on growth performance and immune response of Nile tilapia

(Oreochromis niloticus). *Aquaculture, 550*, 737848. https://doi.org/10.1016/j.aquaculture.2021.737848

Sebola, N. A., Mlambo, V., & Mokoboki, H. K. (2020). Chemical characterisation of Moringa oleifera leaf meal and its effect on intestinal morphology and growth of broiler chickens. *Animal Production Science, 60*(16), 1923–1930. https://doi.org/10.1071/AN19625

Su, B., & Chen, X. (2021). Current status and potential of *Moringa oleifera* leaf as an alternative protein source for animal feed: A review of its impact on livestock performance and health. *Frontiers in Veterinary Science, 8*, 685. https://doi.org/10.3389/fvets.2021.707985

Toronto, C. E., & Remington, R. (Eds.). (2020). A Step-by-Step Guide to Conducting an Integrative Review. *Springer International Publishing*. https://doi.org/10.1007/978-3-030-37504-1

Van der Merwe, D., Swan, G. E., & Botha, C. J. (2021). Use of ethnoveterinary medicinal plants in cattle by rural communities in the Free State, South Africa. *Journal of the South African Veterinary Association, 92*, e1–e9. https://doi.org/10.4102/jsava.v92i0.2073

Wanzala, W., Zessin, K. H., Kyule, N. M., Baumann, M. P. O., Mathias, E., & Hassanali, A. (2022). Ethnoveterinary medicine: A critical review of its evolution, practices, and integration pathways. *Frontiers in Veterinary Science,9*, 870625. https://doi.org/10.3389/fvets.2022.870625

Xiao, X., Wang, J., Song, Z., Jiao, H., & Lin, H. (2021). Effects of dietary *Moringa oleifera* leaf meal on the immune function and intestinal microbiota of yellow-feathered broilers. *Poultry Science, 100*(11), 101437. https://doi.org/10.1016/j.psj.2021.101437

Yousaf, M. S., & Rehman, H. (2021). *Moringa oleifera* leaf meal as a phytogenic feed additive in broiler diets: Effects on performance and gut health. *Tropical Animal Health and Production,53*(4), 415. https://doi.org/10.1007/s11250-021-02851-2

Zanu, H. K., & Kpogo, L. A. (2022). Effects of *Moringa oleifera* leaf extract on Newcastle disease vaccination response in village chickens. *Ghanaian Journal of Animal Science, 13*(1), 45–54.