



PHYTOCHEMICAL ANALYSIS AND IN VITRO EFFECTS OF *Solanum dasyphyllum* FRUIT EXTRACT ON *EIMERIA* IN BROILERS, JOS, NIGERIA

¹Akpojosevbe, E. J., ²Sawa, F. B. J. and ²Buba, T.

¹National Veterinary Research Institute, Vom (NVRI)

²Department of Biological Science, Abubakar Tafawa Balewa University, Bauchi, Bauchi State

Corresponding email: edibimi@gmail.com, GSM: 08037169128, 08121313105

ABSTRACT

The study evaluated the phytochemical composition, gas chromatography-mass spectrometry (GC-MS) analysis and in vitro anticoccidial effects of *Solanum dasyphyllum* fruit extract on *Eimeria* species in broilers. Fresh fruits were collected from the National Veterinary Research Institute (NVRI), Jos, Plateau State, Nigeria, authenticated, air-dried, pulverized, and extracted using 70% ethanol. Stock solutions (100 mg/mL) and lower concentrations (50 and 25 mg/mL) were prepared for in vitro testing. Phytochemical screening and GC-MS analysis were conducted. Mixed *Eimeria* oocysts were obtained from NVRI Parasitology Division. In vitro assays evaluated oocyst sporulation (24–48 h) and sporozoite viability (72 h). Phytochemical screening revealed saponins, tannins, flavonoids, alkaloids, quinones, coumarins, phenones, and steroids/triterpenoids. GC-MS detected six major compounds, including 9-octadecenoic acid methyl ester (37.3%). In vitro, 50 and 100 mg/mL extract completely inhibited oocyst sporulation at 48 h, while 25 mg/mL reduced sporulated oocysts from 80.67 ± 16.9 to 6.33 ± 3.5 . Sporozoite viability decreased to 7.33–8.67 with non-viable counts increasing to 100.67–141.67, comparable to Amprolium. In conclusion, *S. dasyphyllum* fruit extract contains bioactive compounds with potent anticoccidial activity of *S. dasyphyllum* fruit extract can serve as a natural alternative for coccidiosis management in broilers, and further studies should investigate its safety and efficacy in large-scale trials.

Keywords: *Solanum dasyphyllum*, Phytochemical, Composition, Anticoccidial, *Eimeria* species,

INTRODUCTION

Poultry farming is one of the fastest-growing sectors in global animal agriculture. In 2023, global poultry meat production reached 146 million tons, accounting for nearly 40% of total meat output (FAO, 2023). This growth is driven by population increase, rising incomes, and the demand for affordable animal protein. Over the past five decades, production has increased more than eightfold, from 15 million tons in 1970 to over 137 million tons in 2020 (Poultry World, 2024). The poultry industry supports food security, provides employment, and contributes to poverty reduction, particularly in developing countries. In Nigeria, poultry farming is economically significant, with an estimated 180 million birds, making it the second-largest producer in Africa (CSIRO, 2021). The sector generates about USD 4.2 billion and provides employment to over 14 million people (NIPC, 2020; WEF, 2023). Despite this, the industry faces challenges such as high feed costs, dependence on imported feed ingredients, limited access to quality chicks and vaccines, and outbreaks of diseases like coccidiosis (Agroberichten Buitenland, 2020).

Coccidiosis, caused by *Eimeria* spp., is a major parasitic disease affecting poultry, with *E. acervulina* and *E. tenella* being the most prevalent species (Allen & Fetterer, 2021; Bafundo, 2025). The disease impairs growth, reduces feed efficiency, and increases mortality, resulting in estimated global economic losses of £10.4 billion annually (Blake *et al.*, 2020; Bestman *et al.*, 2021). Conventional control methods chemotherapy, vaccination, and chemical disinfectants face limitations such as drug resistance, residue accumulation, toxicity, and high costs (Chapman & Jeffers, 2012; FAO, 2023; Reid & McDougald, 2022). Recently, plant-based alternatives have gained attention due to their bioactive phytochemicals, including tannins, organic acids, and essential oils, which have demonstrated efficacy in reducing gastrointestinal infections and improving poultry performance (Abd El-Hack *et al.*, 2022; Obianwuna *et al.*, 2024). *Solanum dasyphyllum*, a shrub native to South America and found in Africa, contains bioactive compounds traditionally used for medicinal purposes,



making it a promising candidate for alternative coccidiosis management (Abd-elmegeed *et al.*, 2024; Chidambaram *et al.*, 2022; Belitibo *et al.*, 2025).

Despite the economic importance of poultry in Nigeria, coccidiosis remains a major constraint, causing significant production losses. Conventional anticoccidial drugs are limited by resistance, toxicity, and cost, while safe, effective, and affordable alternatives remain underexplored. The study aimed to evaluate the phytochemical composition, GC-MS analysis and *in vitro* effects of *Solanum dasyphyllum* fruit extract on *Eimeria* species in broilers. This study is justified by the need to develop safe, natural, and cost-effective alternatives to conventional anticoccidial drugs, thereby improving poultry health, productivity, and reducing reliance on chemical therapeutics.

MATERIALS AND METHODS

Study Area

The study was carried out on July, 2025 at National Veterinary Research Institute (NVRI), Vom, in Jos South, Plateau State. Jos, a prominent city in central Nigeria, is the capital of Plateau State and stands out for various reasons. Geographically, Jos is perched on the Jos Plateau, an elevated area with an average height of around 1,200 meters above sea level. This highland location grants Jos a moderate and cooler climate, making it a sought-after destination for those looking to escape Nigeria's usual hot and humid weather.

Collection of Plant Materials

The fresh fruits of (*Solanum dasyphyllum*) were collected from the premises of National Veterinary Research Institute (NVRI) Jos, Plateau state, Nigeria. Botanical identification and authentication were done at Federal College of Forestry, Jos, Plateau state, Nigeria.

Processing and Extraction of Fruits

The fresh fruits (*Solanum dasyphyllum*) were washed with clean tap water and sliced into small pieces. They were then air dried under a shade for two weeks. The dried fruits were pulverized into fine powder using mortar and pestle.

Extraction of fruits

Ethanolic extracts were obtained by the procedure described by Zhang *et al.*, (2018). Five hundred (500) grams of the pulverized plant was macerated in 2.5 L of 70% Ethanol. This mixture was shaken daily and allowed to stay for 72 hours. It was then filtered using sieves and Whatman no 1 filter paper. The filtrate was concentrated by evaporating the solvent at 45°C using a rotary evaporator (Buchi R-200) to obtain the extracts. The extract was kept in a refrigerator at 4°C for further processing.

Preparation of stock/test solutions

A 100 mg/mL stock solution of the ethanolic fruit extract was prepared by dissolving 5 g of dried extract in 50 mL of distilled water. Lower concentrations (50 and 25 mg/mL) were obtained from this stock by serial two-fold dilution for oocysticidal testing.

Phytochemical screening

The phytochemical constituents of the fruit extract were determined according to the methods adopted by Builders *et al.* (2011) to test for the presence of phenolic compounds, alkaloids, flavonoids, polyphenols, tannins, saponin, triterpenes and steroids (qualitative phytochemical analysis).

GC-MS chromatographic analysis of crude extracts

The total chemical compositions of the plant extract were evaluated using gas chromatography mass spectrometry

Source of oocysts

Mixed *Eimeria* oocyst suspension was obtained by the researcher with the help of Laboratory Technicians from Parasitology Division of the National Veterinary Research Institute (NVRI), Vom, Plateau State.

Counting of *Eimeria* oocysts

Oocyst counts were performed using a modified McMaster chamber. Two milliliters of homogenized oocyst suspension were mixed with 8 mL of saturated sodium chloride solution (specific gravity 1.2) and used to fill two chambers. After standing for 5 minutes, oocysts were



counted less than 10×10 magnification and the total from both chambers was multiplied by 50 to obtain the final count (Al-Jumaili, 2013; Adams *et al.*, 2022).

Sporulation of *Eimeria* oocysts

The *Eimeria* oocysts were sporulated in petri-dishes of about 6 mm thickness containing 2.5% potassium dichromate solution at 25-29°C and 60- 80% humidity for 72 hours in the laboratory. These petri-dishes were aspirated with sterile Pasteur pipette frequently to ensure the oxygenation (Lavery *et al.*, 2023). The sporulated oocysts were cleaned of potassium dichromate by centrifugation at 2,000 rpm for 5 min with 3.8% sodium hypochlorite solution and distilled water. The cleaned oocysts were stored in distilled water in a refrigerator until required for use (Ahmad *et al.*, 2024).

In vitro oocysticidal effects of ethanolic extracts of *S. dasyphyllum* fruits

The in vitro oocysticidal activity of *Solanum dasyphyllum* ethanolic fruit extract was evaluated against unsporulated *Eimeria* oocysts using three concentrations (25, 50, and 100 mg/mL), alongside Amprolium (1 mg/mL) as the positive control and distilled water as the negative control (Tchodo *et al.*, 2024). A 0.01 mL suspension containing 6,000 oocysts was added to each Petri dish and incubated at room temperature (24–28 °C) with periodic mixing. After 24 and 48 hours, 0.1 mL from each setup was examined microscopically to count sporulated and non-sporulated oocysts. The percentage inhibition of sporulation was then calculated following the method of Tchodo *et al.* (2024).

$$\text{Sporulation inhibition (Sp) percentage (\%)} = \frac{\text{Sp \% of control} - \text{Sp \% of extract}}{\text{Sp \% of control}} \times 100$$

Statistical Analysis

The data were subjected to SPSS version 23 and one-way ANOVA was used to analyze the data generated in the course of the experiment. Tukey's post-hoc test was used to clarify specific differences between treatments and Tukey's HSD was used to group treatments into different homogeneous subsets.

RESULTS AND DISCUSSION

Phytochemical Composition of *S. dasyphyllum*

Preliminary phytochemical screening of the ethanolic fruit extract of *Solanum dasyphyllum* revealed the presence of saponins, tannins, flavonoids, alkaloids, quinones, coumarins, phenones, and steroids/triterpenoids (Table 1). These secondary metabolites are widely recognized for their antimicrobial, antioxidant, and antiparasitic activities, which likely contribute to the biological effects observed in this study. Flavonoids are particularly potent antioxidants capable of mitigating oxidative stress and enhancing immune defenses (Alharthi *et al.*, 2024; Singh *et al.*, 2024). Alkaloids and flavonoids have also been reported to interfere with key enzymatic and membrane functions in parasites, thereby inhibiting their development and survival (Piao *et al.*, 2023; Prasad *et al.*, 2024). Likewise, saponins exert antiparasitic action by disrupting protozoan cell membrane integrity, ultimately causing cell lysis (Alharthi *et al.*, 2024). Additional evidence demonstrates that plant extracts rich in flavonoids, alkaloids, and saponins possess strong antimicrobial and anti-inflammatory activities, supporting their relevance as bioactive constituents (Suyambumani *et al.*, 2024). The detection of these compounds in the present study therefore provides a credible biochemical basis for the observed anticoccidial potential of the extract.

Table 1: Results of Phytochemical Screening of *S. dasyphyllum*

Phytochemical	Result
Saponins	+
Tannins	+
Flavonoids	+
Alkaloids	+
Quinones	+
Coumarins	+
Phenones	+
Steroids/Triterpenoid	+

"+" = detected

GC-MS Chromatogram for the Whole *S. dasyphyllum* Extract

The GC-MS chromatogram (Fig. 1) illustrates the chemical profile of the *S. dasyphyllum* fruit extract. The Y-axis stands for the Detector Response/Signal intensity which means the abundance or intensity of the ions detected by the mass spectrometer while the X-axis represents the retention time (minutes or seconds) i.e. the time it takes for each compound to travel through the GC column and be detected. Each peak on the chromatogram corresponds to a compound identified based on its retention time and peak area. The peak area reflects its relative abundance in the extract. A total of six major compounds were identified, as outlined in Table 4.2, with their retention times ranging from 17.339 to 25.881 minutes.

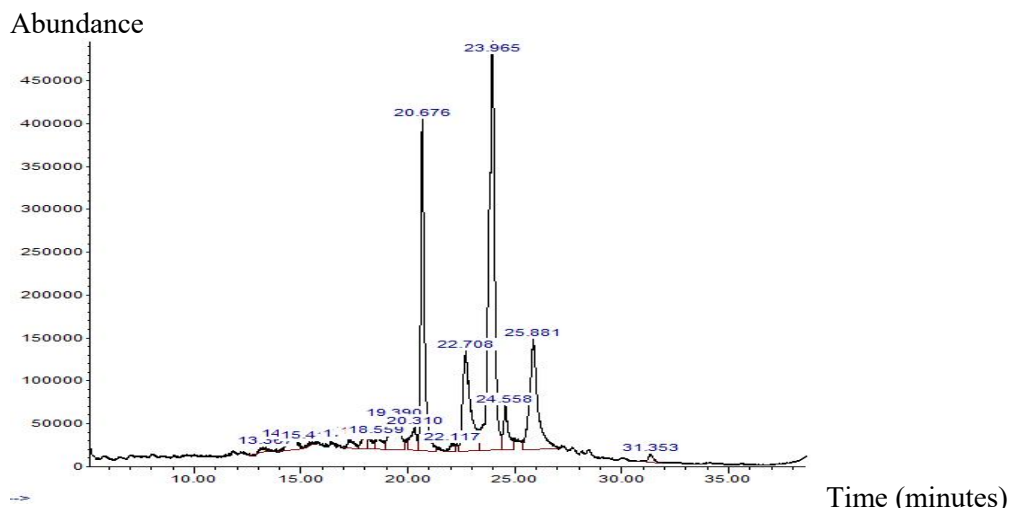


Figure 1: GC-MS Chromatogram for the Whole *S. dasyphyllum* Extract

Bioactive Compounds Detected in the *S. dasyphyllum* Fruit Extract

Gas chromatography–mass spectrometry (GC-MS) analysis of the ethanolic extract of *Solanum dasyphyllum* revealed several bioactive compounds, including fatty acids (pentanoic acid, pentadecanoic acid methyl ester), fatty acid methyl esters (9-octadecenoic acid methyl ester), keto oximes, alkanes, and polyacetylenes. These compounds possess antimicrobial, antioxidant, and immunomodulatory properties linked to coccidial inhibition (Xie *et al.*, 2022). The dominance of 9-octadecenoic acid methyl ester, known for its anti-inflammatory action, indicates a major role in the extract’s therapeutic potential (Yu *et al.*, 2024; Hagr *et al.*, 2018). Cyclopentane, 1-Methyl-2-(2-Propenyl)-, Trans-, and acetylacetone monoxime further contribute antibacterial, antifungal, and antioxidant effects (Chug & Brisbois, 2022; Singh *et al.*, 2025), suggesting that the anticoccidial activity of *S. dasyphyllum* likely results from synergistic interactions among these bioactive constituents.

Table 2: Bioactive Compounds Detected in the *S. dasyphyllum* Fruit Extract

S/N	Retention Time	% Peak Area	Compound	Family of Compound	Ref	CAS	Similarity Index
1	17.339	0.82	Acetylacetone, monoxime	Keto-oxime	7889	1000298-65-7	91
2	19.390	4.90	1,5-Heptadien-3-yne	polyacetylene	2493	003511-27-1	91
3	22.708	12.42	Pentanoic acid	Fatty acid	4317	000109-52-4	91
4	25.881	14.02	Cyclopentane, 1-methyl-2-(2-propenyl)-, trans-	Alkane	10930	050746-53-7	90
5	20.676	18.40	Pentadecanoic acid, 14-methyl-, methyl ester	Fatty acid methyl esters	130841	005129-60-2	96
6	23.965	37.30	9-Octadecenoic acid (Z)-, methyl ester	Fatty acid methyl ester	155751	000112-62-9	90

***In-vitro* Effects of Ethanolic Extract of *S. dasyphyllum* Fruit on *Eimeria* Oocysts after 24 and 48 Hrs.**

Table 3 summarizes the *in vitro* effects of *Solanum dasyphyllum* ethanolic fruit extract on *Eimeria* oocyst sporulation at 25, 50, and 100 mg/mL concentrations after 24 and 48 hours. Sporulated oocysts decreased significantly with increasing extract concentration, showing complete inhibition at 50 and 100 mg/mL after 48 hours comparable to Amprolium (1 mg/mL) while the negative control (distilled water) maintained high sporulation levels. Correspondingly, non-sporulated oocysts increased with extract concentration, confirming the extract's disruption of oocyst development. These results demonstrate a clear dose-dependent inhibitory effect, indicating potent anticoccidial activity. Similar dose-dependent inhibition has been reported with *Vitis vinifera* (Abbas *et al.*, 2020), *Sarcocephalus latifolius* (Kamirou *et al.*, 2023), and *Calotropis procera* (Murshed *et al.*, 2023). The observed efficacy suggests that *S. dasyphyllum*'s phytochemicals may act synergistically to block *Eimeria* sporulation, highlighting its promise as a natural anticoccidial agent pending further *in vivo* validation.

Table 3: *In-vitro* Effects of Ethanolic Extract of *S. dasyphyllum* Fruit on *Eimeria* Oocysts after 24 and 48 Hrs.

Treatments	Sporulated		Non Sporulated	
	24hr	48hr	24hr	48hr
25 mg/ml	32.67±5.8 ^a	6.33±3.5 ^a	23.67±5.1 ^b	56.67±14.5 ^{bc}
50 mg/ml	19.33±6.8 ^a	0.00±0 ^a	19.33±4.0 ^{ab}	57.00±13.2 ^{bc}
100 mg/ml	11.00±2.6 ^a	0.00±0 ^a	21.33±9.1 ^{ab}	29.67±4.5 ^b
1 mg/ml Amprolium (+Ve Control)	17.67±3.1 ^a	0.00±0 ^a	70.33±5.0 ^c	71.00±13.5 ^c
Distilled Water (-Ve Control)	80.67±16.9 ^b	39.00±22.9 ^b	6.66±5.0 ^a	0.00±0 ^a

The results are the mean ± SD of triplicate tests. Values carrying different letter superscripts are significantly different $P < 0.05$.

***In-vitro* Effects of Extract of *S. dasyphyllum* Fruit on Sporozoites after 72hr**

Table 4 shows the *in-vitro* effects of *Solanum dasyphyllum* ethanolic fruit extract on *Eimeria* sporozoites after 72 hours. The extract significantly reduced viable sporozoites (7.33 ± 1.5 – 8.67 ± 2.5) compared with the negative control (132.00 ± 27.9), while markedly increasing non-viable sporozoites (100.67 ± 4.5 – 141.67 ± 28.4). The pattern closely resembled that of Amprolium (1 mg/mL), which showed few intact (4.33 ± 2.3) and many deformed sporozoites (116.00 ± 39.1), confirming the extract's strong sporozoitocidal effect. These results indicate that *S. dasyphyllum* disrupts sporozoite integrity and viability, possibly through mechanisms similar to synthetic anticoccidials. Comparable findings have been reported with *Calotropis procera* (Murshed *et al.*, 2023; 2024), *Sarcocephalus latifolius* (Tchodo *et al.*, 2025), and *Citrus aurantium* (Murshed *et al.*, 2024), where plant extracts caused dose-dependent reductions in *Eimeria* viability. Such effects are generally attributed to phenolic and flavonoid compounds that compromise parasite membranes or induce oxidative stress (Tchodo *et al.*, 2023; Tchodo *et al.*, 2024). The findings therefore suggest that *S. dasyphyllum* fruit extract possesses potent, concentration-dependent anticoccidial properties worthy of further *in-vivo* validation.

Table 4: *In-vitro* Effects of Ethanolic Extract of *S. dasyphyllum* Fruit on Sporozoites After 72 hrs

Treatments	Viable Sporozoites (Intact)	Non-Viable Sporozoites (Deformed)
25 mg/ml	8.67±2.5 ^a	101.33±29.0 ^b
50 mg/ml	7.33±1.5 ^a	100.67±4.5 ^b
100 mg/ml	7.67±4.0 ^a	141.67±28.4 ^b
1 mg/ml Amprolium (+Ve Control)	4.33±2.3 ^a	116.00±39.1 ^b
Distilled Water (-Ve Control)	132.00±27.9 ^b	4.67±0.58 ^a

The results are the mean ± SD of triplicate tests. Values carrying different letter superscripts are significantly different $P < 0.05$.

CONCLUSION AND RECOMMENDATION

The study concludes that *Solanum dasyphyllum* fruit extract possesses potent anticoccidial properties against *Eimeria* species in broiler chickens, supported by its rich phytochemical composition including saponins, flavonoids, tannins, alkaloids, and fatty acid methyl esters. In vitro results showed that concentrations of 50 and 100 mg/mL effectively inhibited oocyst sporulation and caused significant sporozoite deformation. These findings indicate that *S. dasyphyllum* extract could serve as an effective natural alternative to synthetic anticoccidials such as Amprolium. It is therefore recommended that further studies be conducted to isolate and characterize the bioactive compounds responsible for this activity, assess their safety and pharmacodynamics, and perform field trials to validate the extract's efficacy and suitability for integration into sustainable poultry health management programs.

REFERENCES

- Abbas, R. Z., Hussain, K., Mahmood, M. S., Iqbal, Z., Khan, M. K., Saleemi, M. K., & Zia, M. A. (2020). Anticoccidial potential of *Vitis vinifera* (grape) seed extract against *Eimeria tenella* infection in broiler chickens. *Pakistan Veterinary Journal*, *40*(2): 213–218. <https://doi.org/10.29261/pakvetj/2020.040>
- Abd El-Hack, M. E., El-Saadony, M. T., Salem, H. M., El-Tahan, A. M., Soliman, M. M., Youssef, G. B. A., ... & El-kott, A. F. (2022). Alternatives to antibiotics for organic poultry production: Types, modes of action and impacts on bird's health and production. *Poultry Science*, *101*(4): 101696. <https://doi.org/10.1016/j.psj.2022.101696>
- Abd-Elmegeed, A. S. S., Abd-Allah, H. S., Mohamed, A. A., & Ghaber, B. M. (2024). Medicinal plants: Past traditions and hope of tomorrow. *International Journal of Science and Research Archive*, *13*(02): 3789–3797. <https://doi.org/10.30574/ijrsra.2024.13.2.2538>
- Adams, D. S., Pomroy, W. E., & Scott, I. (2022). Image analysis for *Eimeria* oocyst counts and classification. *Veterinary Parasitology: Regional Studies and Reports*, *30*: 107-122. <https://doi.org/10.1016/j.vprsr.2022.100722>
- Agroberichten Buitenland. (2020, June 1). *Piggery and poultry market roadmap for sustainable value-chain development*. <https://www.agroberichtenbuitenland.nl/documenten/rapporten/2020/06/01/piggery-and-poultry-market-roadmap-for-sustainable-value-chain-development> (agroberichtenbuitenland.nl)
- Ahmad, R., Yu, Y.-H., Hua, K.-F., Chen, W.-J., Zaborski, D., Dybus, A., Hsiao, F. S.-H., and Cheng, Y.-H. (2024). Management and control of coccidiosis in poultry — A review. *Animal Bioscience*, *37*(1): 1–15. <https://doi.org/10.5713/ab.23.0189>
- Alharthi, F., Althagafi, H. A., Jafri, I., Oyouni, A. A. A., Althaqafi, M. M., Al-Hijab, L. Y. A., Al-Hazmi, N. E., Elagib, S. M., & Naguib, D. M. (2024). *Phytochemical composition and bioactivities of some hydrophytes: Antioxidant, antiparasitic, antibacterial, and anticancer properties and mechanisms*. *Plants*, *13*(15): 2148. <https://doi.org/10.3390/plants13152148>
- Al-Jumaili, O. A. R. (2013). Compare between two methods for diagnosis of coccidia in broiler chicken. *AL-Qadisiya Journal of Veterinary Medical Science*, *12*(2): 61-67.



- Allen, P. C., and Fetterer, R. H. (2021). Recent advances in the biology of *Eimeria* species infecting chickens. *Avian Pathology*, **50**(3): 201–215. <https://doi.org/10.1080/03079457.2021.1889462>.
- Bafundo, K. (2025). Current thinking on *Eimeria* spp. in poultry and potential for advancements in control. *Animals*, **15**(3): 424–431. <https://doi.org/10.3390/ani15030424>
- Belitibo, D. B., Meressa, A., Negassa, T., Abebe, A., Degu, S., Endale, M., Assamo, F. T., Ayana, T. A., & Gurmessa, G. T. (2025). In vitro antimicrobial and cytotoxic evaluation of leaf, root, and stem extracts of *Solanum dasyphyllum* and *Dovyalis abyssinica*. *Frontiers in Pharmacology*, **16**: 1529–1534. <https://doi.org/10.3389/fphar.2025.1529854>
- Bestman, M., van Niekerk, T. G. C. M., de Haas, E. N., Ferrante, V., and Gunnarsson, S. (2021). Parasitic worms in Dutch organic laying hens – Relation with range use. In *Proceedings of the IAHA Pre-Conference on Organic Animal Husbandry* (pp. 62–65). IFOAM.
- Blake, D. P., Knox, J., Dehaeck, B., Huntington, B., Rathinam, T., Ravipati, V., Aime, S., Pastor-Fernández, I., Marugan-Hernandez, V., and Tomley, F. M. (2020). Re-calculating the cost of coccidiosis in chickens. *Veterinary Research*, **51**(1): 115. <https://doi.org/10.1186/s13567-020-00837-2>
- Builders, P. F., Isimi, C. Y., & Kunle, O. O. (2011). Characterization of mucilage from *Cissus populnea* (Guill. & Perr.) as a suspending agent. *Acta Pharmaceutica Scientia*, **53**(1): 1–14.
- Chapman, H. D., and Jeffers, T. K. (2012). Coccidiosis in poultry: Current challenges and control strategies. *Poultry Science*, **101**(2): 101–107. <https://doi.org/10.1016/j.psj.2021.101567>.
- Chidambaram, K., Alqahtani, T., Alghazwani, Y., Aldahish, A., Annadurai, S., Venkatesan, K., Dhandapani, K., Thilagam, E., Venkatesan, K., Paulsamy, P., Vasudevan, R., & Kandasamy, G. (2022). Medicinal plants of *Solanum* species: The promising sources of phyto-insecticidal compounds. *Journal of Tropical Medicine*, 2022, Article 4952221. <https://doi.org/10.1155/2022/4952221>
- CSIRO. (2021). *Poultry production in Nigeria: Industry snapshot* [Fact sheet]. Retrieved from <https://research.csiro.au/livegaps/wp-content/uploads/sites/37/2021/03/1.-LiveGAPS-factsheet-Poultry-production-in-Nigeria-22-April-2020.pdf>
- Food and Agriculture Organization of the United Nations. (2023). Meat and meat products – Market summary (CC3020en). FAO. https://openknowledge.fao.org/bitstreams/3/cc3020en/cc3020en_meat.pdf
- Hagr, T. E., Ali, K. S., Satti, A. A. E., & Omer, S. A. (2018). GC-MS analysis, phytochemical, and antimicrobial activity of sudanese *Nigella sativa* (L) oil. *Eur. J. Biomed. Pharmaceut. Sci*, **5**(4): 23–29.
- Kamirou, M. M., Kaboré, A., Guissou, I. P., Bassolé, I. H. N., & Traoré, A. (2023). Anticoccidial and antioxidant activities of *Sarcocephalus latifolius* root extract against *Eimeria* spp. oocysts: An in vitro evaluation. *Journal of Parasitic Diseases*, **47**(1): 230–239. <https://doi.org/10.1007/s12639-022-01530-7>
- Kasem, S. M., Mira, N. M., Helal, I. B., & Mahfouz, M. E. (2022). In vitro study to evaluate the efficacy of ultrasonicated ethanolic extract of *Rosmarinus officinalis* and its chitosan-based nanoparticles against *Eimeria tenella* oocysts of chickens. *AAPS PharmSciTech*. <https://doi.org/10.1208/s12249-022-02445-z>
- Laverty, L. (2023). *In vitro and in vivo Evaluation of Antimicrobial Activity, Oocyst Sporulation Rate, Oocyst Integrity and Oocyst Infectivity in Eimeria maxima M6 Oocyst Suspensions Treated with Chlorhexidine Salts in Comparison with Potassium Dichromate*. Graduate Theses and Dissertations. Retrieved from <https://scholarworks.uark.edu/etd/5161>
- Murshed, M., Aljawdah, H. M. A., Mares, M., & Al-Quraishy, S. (2023). In vitro: The effects of the anticoccidial activities of *Calotropis procera* leaf extracts on *Eimeria stiedae* oocysts isolated from rabbits. *Molecules*, **28**(8): 3352. <https://doi.org/10.3390/molecules28083352>
- Murshed, M., Al-Tamimi, J., Aljawdah, H. M. A., Mares, M., & Al-Quraishy, S. (2024). Effect of *Calotropis procera* extract against *Eimeria piriformis* oocyst- and sporozoite-infected rabbits. *Tropical Journal of Pharmaceutical Research*, **23**(6): 933–940.



- Murshed, M., Rahman, M. M., Kabir, M. H., & Islam, M. R. (2023). Antiparasitic and antimicrobial activities of *Calotropis procera* leaf extracts: Evaluation of efficacy against protozoan and helminth parasites. *BMC Complementary Medicine and Therapies*, *23*: 112. <https://doi.org/10.1186/s12906-023-03992-3>
- Nigerian Investment Promotion Commission. (2020). *Investment opportunities in Nigeria's poultry value chain*. NIPC.
- Obianwuna, U. E., Chang, X., Oleforuh-Okoleh, V. U., Onu, P. N., Zhang, H., Qiu, K. & Wu, S. (2024). Phytobiotics in poultry: Revolutionizing broiler chicken nutrition with plant-derived gut health enhancers. *Journal of Animal Science and Biotechnology*, *15*: 58-64. <https://doi.org/10.1186/s40104-024-01101-9>
- Piao, M., Tu, Y., Zhang, N., Diao, Q., & Bi, Y. (2023). *Advances in the application of phytogetic extracts as antioxidants and their potential mechanisms in ruminants*. *Antioxidants*, *12*(4): 879-884. <https://doi.org/10.3390/antiox12040879>
- Poultry World. (2024). *Remarkable dynamics of the global poultry industry*. Retrieved from <https://www.poultryworld.net/the-industrymarkets/market-trends-analysis-the-industrymarkets-2/remarkable-dynamics-of-the-global-poultry-industry-2/> (poultryworld.net)
- Prasad, P., Mansoori, A., Prajapati, N., Tripathi, J., Sharma, K., Kumar, A., & Das, S. N. (2024). *Phytochemical screening and antimicrobial activities of Guizotia abyssinica L. leaf and flower extracts*. *Journal of Natural Pesticide Research*, *9*, 100-108. <https://doi.org/10.1016/j.napere.2024.100083>
- Reid, W. M., and McDougald, L. R. (2022). Advances in coccidiosis control: Challenges and opportunities in poultry health management. *Avian Diseases*, *64*(4): 396-403. <https://doi.org/10.1637/aviandiseases-D-22-00045>.
- Singh, S., Naquvi, K. J., Siddiqui, A. W., & Singh, A. (2024). *Phytochemical investigation, evaluation of total phenolic & flavonoid contents and antioxidant activity of polyherbal extracts*. *African Journal of Biomedical Research*, *27*(4): 8153-8165. <https://doi.org/10.53555/AJBR.v27i4S.5169>
- Souza, G. C. d., Esteves, G. F., Volpato, F. A., Miotto, R., Mores, M. A. Z., Ibelli, A. M. G., & Bastos, A. P. (2024). Effects of varying concentrations of *Eimeria* challenge on the intestinal integrity of broiler chickens. *Poultry*, *3*(1): 1-14. <https://doi.org/10.3390/poultry3010001>.
- Su, L., Huang, S., Huang, Y., Bai, X., Zhang, R., Lei, Y., & Wang, X. (2024). Effects of *Eimeria* challenge on growth performance, intestine integrity, and cecal microbial diversity and composition of yellow broilers. *Poultry Science*, *103*(12): 104470. <https://doi.org/10.1016/j.psj.2024.104470>
- Suyambumani, S., Pandiyan, J., Wong, L. S., Djearamane, S., Mathanmohun, M., & Sagadevan, S. (2024). *Phytochemical analysis and antimicrobial potential of Bauhinia tomentosa leaf extracts*. *Journal of Phytology*, *16*: 41-48. <https://doi.org/10.25081/jp.2024.v16.8456>
- Tchodo, F. G., Dakpogan, H. B., Gambogou, B., Adjei-Mensah, B., Sanvee, S., Pitala, W., ... Bakoma, B. (2025). In vitro evaluation of the inhibitory effects and antioxidant properties of hydro-ethanolic extracts from the roots of *Sarcocephalus latifolius* against *Eimeria* spp. sporozoites. *Journal of Herbmed Pharmacology*, *14*(2): 208-216.
- Tchodo, F. G., Dakpogan, H. B., Sanvee, S., Adjei-Mensah, B., Kpomasse, C. C., Karou, S., Pitala, W., Tona, K., & Bakoma, B. (2024). The Anticoccidial In Vitro Effects and Antioxidant Properties of Several Plants Traditionally Used for Coccidiosis in Togo. *Veterinary sciences*, *11*(8): 345. <https://doi.org/10.3390/vetsci11080345>
- World Economic Forum. (2023, September). *5 ways to strengthen Nigeria's poultry supply chain*. <https://www.weforum.org/stories/2023/09/5-ways-to-strengthen-nigerias-poultry-supply-chain/>
- Xie, C., Wang, S., Cao, M., Xiong, W., & Wu, L. (2022). (E)-9-Octadecenoic Acid Ethyl Ester Derived from Lotus Seedpod Ameliorates Inflammatory Responses by Regulating MAPKs and NF- κ B Signalling Pathways in LPS-Induced RAW264.7 Macrophages. Evidence-based



Nigerian Journal of Agriculture and Agricultural Technology (NJAAT)
Volume 5, Number 4B, December, 2025
ISSN (Print): 2811-1885; ISSN (Online): 2811-1893



complementary and alternative medicine : eCAM, 2022, 6731360.
<https://doi.org/10.1155/2022/6731360>

- Yu, Z., Liu, X., Zhang, B., Huang, K., Xu, Y., & Li, Y. (2024). Efficacy of liver free and chitosan against *Eimeria tenella* in broiler chickens: effects on oocyst shedding and lesion scores. *BMC Veterinary Research*, **20**: Article 124. <https://doi.org/10.1186/s12917-024-04124-6>
- Zhang, Q.-W., Lin, L.-G., & Ye, W.-C. (2018). Techniques for extraction and isolation of natural products: a comprehensive review. *Chinese Medicine*, *13*(20): 234-245. <https://doi.org/10.1186/s13020-018-0177-x>