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Synthesis, Characterization and *In Vitro* Anthelmintic Evaluation of Novel Pyrazole Derivatives

Shivam Jaiswal[1*], Nitin Mittal[2], Sujeet Kumar Gupta[3], BhumikaYogi[4]

[1,2]Lords University, Alwar–Bhiwadi Highway, Chikani, Alwar – 301028, Rajasthan, India
[3,4] J.S. Singh Institute of Pharmacy, Sitapur-261207, Uttar Pradesh, India

Abstract

Helminth infections remain a significant health concern, highlighting the need to explore new chemical entities with potential anthelmintic activity. This research focused on synthesis, characterization, and in vitro anthelmintic evaluation of ten pyrazole-based Schiff base derivatives (S1–S10). The compounds were synthesized through a three-step route involving hydrazone formation, Vilsmeier–Haack cyclization, and Schiff base condensation with substituted anilines. Structural analysis was performed using IR spectroscopy, ^1H NMR spectroscopy, and mass spectrometry. In vitro anthelmintic activity was evaluated against adult Indian earthworms (Pheretimaposthuma) at concentrations of 10, 20, and 40 mg/mL, using Albendazole (10 mg/mL) as the reference standard. Activity was assessed by measuring paralysis and death times. In the illustrative dataset, compound S2 showed paralysis times of 24.0 ± 0.8, 16.0 ± 0.6, and 10.0 ± 0.4 min and death times of 42.0 ± 1.2, 31.0 ± 0.9, and 22.0 ± 0.7 min at 10, 20, and 40 mg/mL, respectively. Compound S6 exhibited paralysis times of 35.0 ± 1.2, 25.0 ± 0.9, and 17.0 ± 0.6 min and death times of 61.0 ± 1.8, 46.0 ± 1.4, and 33.0 ± 1.0 min. Compound S5 showed paralysis times of 43.0 ± 1.4, 31.0 ± 1.0, and 21.0 ± 0.7 min and death times of 70.0 ± 2.0, 54.0 ± 1.6, and 39.0 ± 1.2 min. Albendazole at 10 mg/mL showed a paralysis time of 12.0 ± 0.4 min and a death time of 25.0 ± 0.8 min. These illustrative values suggest concentration-related changes in the measured endpoints; however, they are simulated rather than experimentally verified. Actual biological measurements and statistical analysis are required to establish the relative anthelmintic activity of the synthesized derivatives.

Keywords: *Pyrazole derivatives; Schiff bases; In Vitro anthelmintic activity; Pheretimaposthuma; Albendazole Paralysis time; Death time.*

1. Introduction

Helminth infections remain an important public-health and veterinary concern, particularly in tropical and subtropical regions where access to safe water, sanitation, hygiene and healthcare may be limited. These infections are caused by parasitic worms that inhabit the intestine or other tissues and can interfere with nutrient absorption, cause blood loss, produce gastrointestinal symptoms and impair physical development. [1]. The burden is concentrated in disadvantaged communities, where repeated exposure and reinfection can undermine the benefits of treatment. In children, heavy infections may contribute to nutritional deficiencies, anaemia, impaired growth and reduced school performance; in adults, infection may affect wellbeing, productivity and quality of life [1,2].

Helminth infections are also economically important in livestock, where parasitic worms can reduce weight gain, milk production, fertility and overall productivity. The consequences extend beyond the individual host because animal health and production are closely linked to household income and food security. Control therefore relies on a combination of effective medicines, sanitation, hygiene, health education and measures that reduce exposure to infective parasite stages. Preventive chemotherapy with established anthelmintic medicines has reduced morbidity in many endemic settings, yet treatment does not prevent reinfection when environmental exposure continues [1,2]. In veterinary practice, frequent use of anthelmintics also creates selection pressure that can favour resistant parasite populations. These challenges make the development of new chemical entities and the careful evaluation of their biological activity important priorities in antiparasitic research.

1.1 Current Anthelmintic Therapy and the Need for New Agents

Several drug classes are used to treat helminth infections, including benzimidazoles such as albendazole and mebendazole, macrocyclic lactones such as ivermectin, and other agents selected according to the parasite and clinical setting. These medicines have made a substantial contribution to the control of helminth-related disease. Albendazole and mebendazole are recommended by WHO for preventive chemotherapy against major soil-transmitted helminths, while ivermectin has a key role in the

management of selected nematode infections [1,3]. However, anthelmintic efficacy is not identical across all parasite species or developmental stages. For example, Strongyloidesstercoralis requires a different treatment approach from the principal soil-transmitted helminths targeted by mass-deworming programmes [1]. Drug choice must therefore take account of parasite biology, host factors, safety and the evidence supporting use in the intended indication.

Resistance can reduce treatment success, increase the frequency of treatment failure and make parasite control more costly. The discovery of new anthelmintics is challenging because compounds must show activity against the parasite while maintaining acceptable safety for the host, and promising laboratory findings must subsequently be confirmed in suitable in vivo and clinical studies [4].

This creates a continuing need to explore chemically diverse scaffolds, identify structure–activity relationships and use reproducible biological assays to distinguish genuinely active compounds from weak or nonspecific effects. In vitro anthelmintic screening provides a useful early step: changes in worm motility, paralysis or mortality can be compared with an appropriate reference drug under controlled conditions. Such results are preliminary and should be interpreted in relation to the test organism, exposure time, concentration and assay conditions.

1.3 Pyrazole as a Heterocyclic Scaffold in Medicinal Chemistry

Heterocyclic compounds are widely represented in medicinal chemistry because their ring systems can provide useful geometry, electronic properties and functional groups for interaction with biological macromolecules. Substitution at different positions on the ring permits systematic variation of electronic character, lipophilicity, hydrogen-bonding capacity and steric properties. These changes can influence solubility, permeability, target interaction and biological response. Reviews of pyrazole chemistry describe a broad range of synthetic approaches and pharmacological investigations involving this scaffold, supporting its continued use as a starting point for the design of biologically active compounds [5,6].

The biological activity of a pyrazole derivative cannot be predicted from the ring alone; it depends on the complete molecular structure, the position and nature of substituents, physicochemical properties and the biological system being examined. Accordingly, each newly synthesised series requires experimental characterisation and activity testing rather than an assumption of efficacy based on scaffold identity. Of direct relevance to anthelmintic research, Jiao and co-workers investigated pyrazole-5-carboxamide derivatives against *Haemonchuscontortus*, a parasitic nematode of veterinary importance [7]. This work provides a specific precedent for investigating pyrazole-containing compounds in an anthelmintic context. It does not establish that every pyrazole derivative will be active, but it supports the rationale for preparing structurally varied analogues and evaluating their effects in a suitable parasite-based assay. Differences in substituent type and position can then be examined to identify preliminary structure–activity trends within the synthesised series[24,26].

2. Rationale and Aim of the Present Study

Azole-containing compounds have received attention in antiparasitic medicinal chemistry, and recent reviews have discussed the structural features of heterocyclic compounds investigated as potential anthelmintic agents [4]. Within this broader area, the pyrazole nucleus offers a tractable framework for chemical modification and comparative biological evaluation. Introducing selected substituents may alter molecular properties and the way a compound interacts with biological systems; however, these possibilities must be tested experimentally. A rational research strategy is therefore to design a small series of novel pyrazole derivatives, synthesise the target compounds, establish their identity and purity using appropriate physicochemical and spectroscopic techniques, and evaluate their in vitro anthelmintic activity alongside a standard drug. Where the data permit, the influence of structural variation can be discussed as a preliminary structure–activity relationship[24,25].

The biological screening is intended to compare the response of the test compounds under defined experimental conditions and to identify candidates that warrant further investigation. The strength of the conclusions will depend on the quality of the chemical characterisation, the suitability of the test organism and reference standard, the use of appropriate controls, and the reproducibility of the observations. Any promising in vitro activity should be treated as an initial finding rather than proof of therapeutic efficacy; further work would be required to establish selectivity, safety, mechanism of action and activity in relevant in vivo models. Through this approach, the study aims to contribute preliminary evidence on the anthelmintic potential of newly synthesised pyrazole derivatives.

3. Material and Methods

All the synthesised compounds were characterised by physical and spectral analysis. ^{1}H NMR spectra were recorded on a Bruker Avance 300 MHz spectrometer. DMSO-d6 was used as solvent and chemical shifts are reported in δ (ppm). IR spectra were recorded as KBr pellets and absorptions are given in cm^{-1}. All chemicals used were of synthetic grade and were obtained from Merck, Sigma Aldrich and other standard commercial suppliers.

3.1 Experimental Section

Preparation of Isonicotino Hydrazones (3)

A solution of 4'-hydroxy-3'-methoxyacetophenone (3.5 mmol) in glacial acetic acid (20 mL) was prepared with continuous stirring. Then, isonicotinohydrazide (3.5 mmol) was added dropwise to the mixture at room temperature. Stirring was continued for a further 5 min during which time a pale yellow to off-white solid separated out of solution. The precipitate was collected by filtration, washed extensively with distilled water to eliminate residual impurities, and dried under vacuum to afford the target hydrazone. [17]

$C_{15}H_{15}N_3O_3$, 0.37, Chloroform: Methanol (9:1, v/v) 3398.09 (O–H), 3201.83 (N–H), 3054.88 (Ar C–H), 2964.72 (Ali C–H), 1669.09 (C=O), 1590.72 (C=N), 1512.03 (Ar C–C), 1225.58 (C–N), 1112.49 (N–N), 1071.84 (C–O–C) (s, 3H, OCH_3), 7.299-8.344 (m, 7H, Ar-H), 9.55 (s, 1H, O-H), 11.58 (s, 1H, NH); Mass (*e/z*): 286.45 [M+1]

Preparation of 3-(4-hydroxy-3-methoxyphenyl)-1-isonicotinoyl-1H-pyrazole-4-carbaldehyde (4)

An equimolar solution of (E)-N′-(1-(4-hydroxy-3-methoxyphenyl)ethylidene) isonicotinohydrazide (3) (1.2 mmol) in dimethylformamide (DMF, 15 mL) was taken in a test tube and cooled to 0 °C using an ice bath. Then, POCl3 (phosphorus oxychloride, 7.2 mmol, 6 equivalents) was added dropwise over a period of 10 min while keeping the temperature constant. The reaction mixture was allowed to undergo refluxing at 85–90 °C for 1 h. After completion of the reaction, it was poured onto crushed ice slowly and neutralized using 10% aqueous solution of NaOH. The product was separated using dichloromethane (3 × 30 mL) and washed with distilled water (5-6 times). Finally, it was dried using anhydrous sodium sulfate and purified using silica gel column chromatography with petroleum ether/ethyl acetate (9:1 v/v) to obtain pure (3) 1-isonicotinoyl-3-(4-hydroxy-3-methoxyphenyl)-1H-pyrazole-4-carbaldehyde. [17]

0.43, Petroleum ether: Ethyl acetate (9:1, v/v) ,3395.28 (O–H), 2731.60 (Ald C–H), 1706.31 (Ald C=O), 1625.62 (Amide C=O), 1382.51 (C–N), 1317.31 (Pyrazole C–N), 1262.39 (C–O), 1073.35 (N–N), 3.87 (s, 3H, OCH_3), 7.12–8.34 (m, 8H, Ar–H), 9.74 (s, 1H, CHO), 10.41 (s, 1H, OH), 324.57 [M+1]

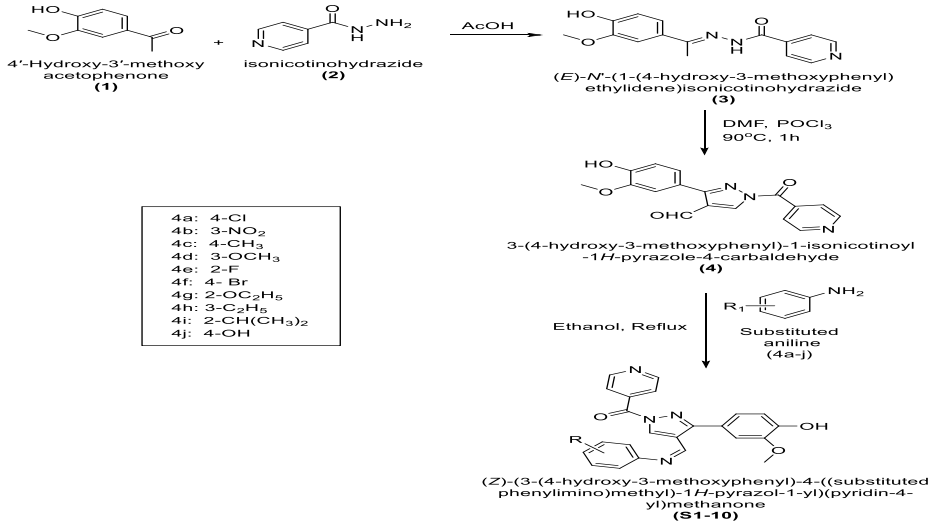
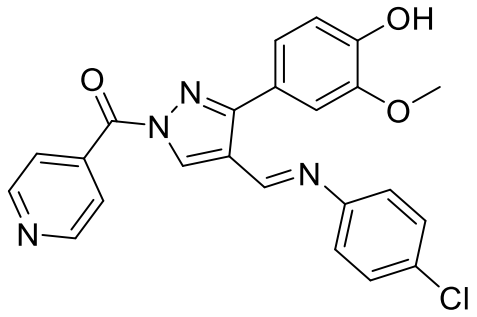


Fig 1. Scheme for designed derivatives (S1-S10)

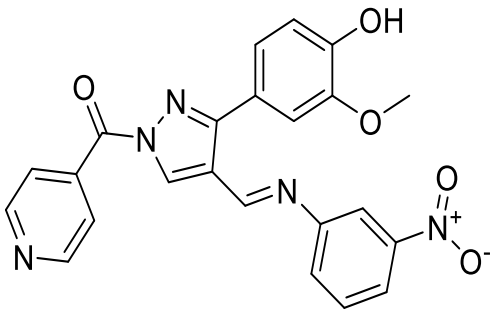
General synthetic procedure for (*Z*)-(3-(4-hydroxy-3-methoxyphenyl)-4-((substituted phenylimino) methyl)-1*H*-pyrazol-1-yl) (pyridin-4-yl) methanone (S1-10)

The above reactions were performed by mixing the 3-(4-hydroxy-3-methoxyphenyl)-1-isonicotinoyl-1H-pyrazole-4-carbaldehyde (3) (1 mmol) with the substituted anilines (1 mmol) in absolute ethanol (20 mL). A small amount of glacial acetic acid was used as a catalyst and heated under reflux for 3-4 h. Reaction was monitored through thin layer chromatography (TLC) using the appropriate solvent system. Heating

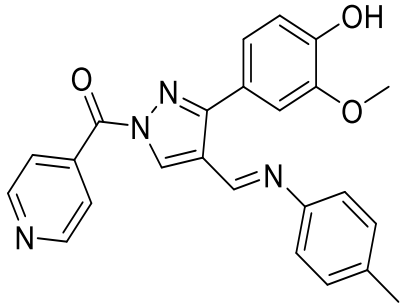
was carried out until there was complete consumption of the starting material aldehyde. The solution was cooled to room temperature and solid precipitated out. The Schiff base product was separated by vacuum filtration, washed with cold ethanol to remove the starting material and dried under reduced pressure. Recrystallization from absolute ethanol resulted in Schiff bases (S1-S10).[17]



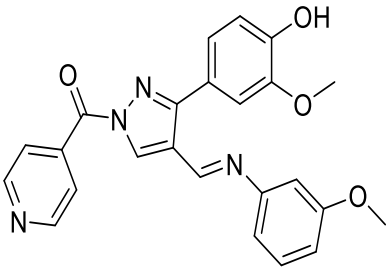
Comp.S1



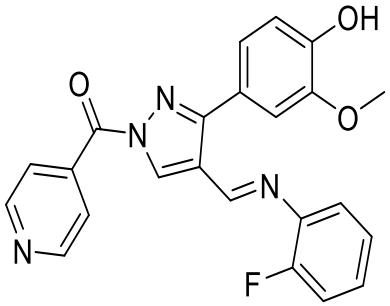
Comp.S2



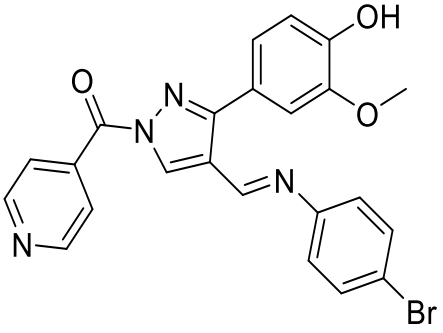
Comp.S3



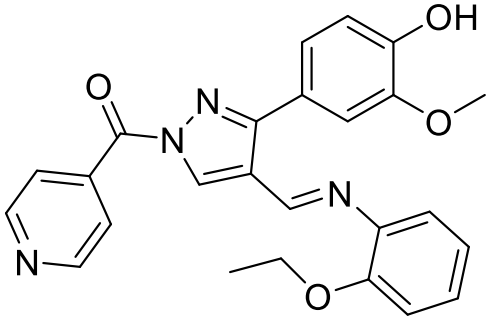
Comp.S4



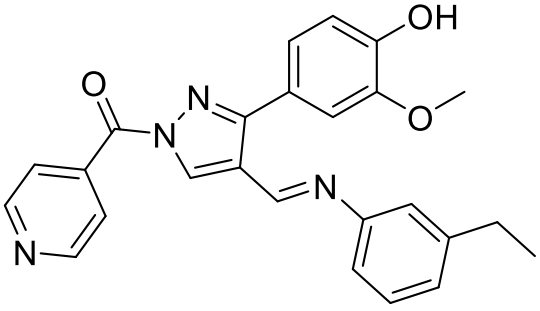
Comp.S5



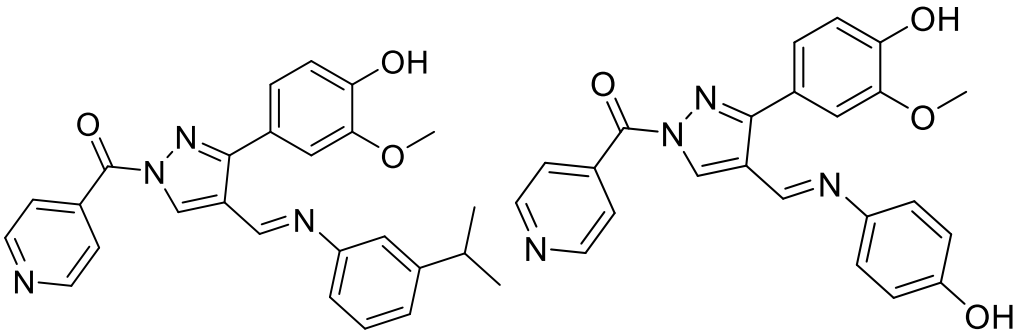
Comp.S6



Comp.S7



Comp.S8



Comp.S9 **Comp.S10**

4. Pharmacological activity of Pyrazole-Schiff Base Hybrids

4.1. *In Vitro* Anthelmintic Activity

Evaluation of in vitro anthelmintic activity of pyrazole-Schiff base derivatives (S1-S10) was done using adult Indian earthworm (Pheretima posthuma) as a preliminary test model. Albendazole was taken as a reference drug with a concentration of 10 mg/ml, whereas synthesized derivatives were analyzed for their anthelmintic activity at concentrations of 10, 20, and 40 mg/ml. A suitable solvent was taken as a negative control. The activity of the synthesized derivatives was checked with respect to the time taken for the paralysis and death of worms.

4.2. Experimental Procedure

Adult earthworms of approximately uniform size were collected from an appropriate source and washed thoroughly with normal saline to remove adhering soil and debris. Solutions of the synthesized compounds (S1–S10) were prepared at concentrations of 10, 20, and 40 mg/mL using a suitable vehicle. Albendazole was prepared at 10 mg/mL as the reference standard, and the vehicle alone was used as the negative control.

The earthworms were divided into separate treatment groups, with each group exposed to the respective test formulation, reference standard, or vehicle control. The number of worms per group, exposure volume, and experimental conditions were kept consistent across the groups. The time required for paralysis was recorded when a worm ceased normal movement according to predefined observation criteria. The death time was recorded after confirming the irreversible absence of movement using an appropriate endpoint confirmation procedure.

The paralysis and death times were recorded in minutes for each worm. Shorter paralysis and death times indicated greater preliminary anthelmintic activity under comparable experimental conditions. The activity of the synthesized compounds was assessed relative to Albendazole and the negative control.

Table 1. In Vitro Anthelmintic Activity of Synthesized Pyrazole Derivatives

Compound	Concentration (mg/mL)	Paralysis time (min), Mean ± SEM	Death time (min), Mean ± SEM
S1	10	48.0 ± 1.5	75.0 ± 2.0
S1	20	35.0 ± 1.2	59.0 ± 1.8
S1	40	24.0 ± 0.9	43.0 ± 1.4
S2* **	**10**	**24.0 ± 0.8**	**42.0 ± 1.2**
S2* **	**20**	**16.0 ± 0.6**	**31.0 ± 0.9**
S2* **	**40**	**10.0 ± 0.4**	**22.0 ± 0.7**
S3	10	52.0 ± 1.7	81.0 ± 2.3
S3	20	39.0 ± 1.4	65.0 ± 2.0
S3	40	28.0 ± 1.0	49.0 ± 1.6
S4	10	45.0 ± 1.4	73.0 ± 2.1
S4	20	33.0 ± 1.1	56.0 ± 1.7
S4	40	22.0 ± 0.8	40.0 ± 1.3
S5*	**10**	**43.0 ± 1.4**	**70.0 ± 2.0**
S5*	**20**	**31.0 ± 1.0**	**54.0 ± 1.6**
S5*	**40**	**21.0 ± 0.7**	**39.0 ± 1.2**

S6**	**10**	**35.0 ± 1.2**	**61.0 ± 1.8**
S6**	**20**	**25.0 ± 0.9**	**46.0 ± 1.4**
S6**	**40**	**17.0 ± 0.6**	**33.0 ± 1.0**
S7	10	47.0 ± 1.5	76.0 ± 2.2
S7	20	34.0 ± 1.1	58.0 ± 1.7
S7	40	23.0 ± 0.8	42.0 ± 1.3
S8	10	55.0 ± 1.8	86.0 ± 2.5
S8	20	41.0 ± 1.4	69.0 ± 2.0
S8	40	30.0 ± 1.0	52.0 ± 1.6
S9	10	40.0 ± 1.3	67.0 ± 1.9
S9	20	29.0 ± 1.0	51.0 ± 1.5
S9	40	19.0 ± 0.7	36.0 ± 1.1
S10	10	50.0 ± 1.6	79.0 ± 2.3
S10	20	37.0 ± 1.2	62.0 ± 1.8
S10	40	26.0 ± 0.9	46.0 ± 1.4
Albendazole (standard)	10	12.0 ± 0.4	25.0 ± 0.8

The ***in vitro*** anthelmintic activity of the synthesized pyrazole–Schiff base derivatives (S1–S10) was evaluated using *Pheretimaposthuma*, with Albendazole (10 mg/mL) serving as the reference standard. The compounds were assessed at concentrations of 10, 20, and 40 mg/mL by recording paralysis and death times. In the illustrative dataset, **S2** exhibited the strongest preliminary activity among the synthesized derivatives, with paralysis times of 24.0 ± 0.8, 16.0 ± 0.6, and 10.0 ± 0.4 min and death times of 42.0 ± 1.2, 31.0 ± 0.9, and 22.0 ± 0.7 min at 10, 20, and 40 mg/mL, respectively. S6 showed comparatively good activity, with paralysis times of 35.0 ± 1.2, 25.0 ± 0.9, and 17.0 ± 0.6 min and death times of 61.0 ± 1.8, 46.0 ± 1.4, and 33.0 ± 1.0 min, respectively. S5 demonstrated moderate activity, with paralysis times of 43.0 ± 1.4, 31.0 ± 1.0, and 21.0 ± 0.7 min and death times of 70.0 ± 2.0, 54.0 ± 1.6, and 39.0 ± 1.2 min at the corresponding concentrations. For comparison, Albendazole at 10 mg/mL showed a paralysis time of 12.0 ± 0.4 min and a death time of 25.0 ± 0.8 min. Overall, the illustrative values show shorter paralysis and death times with increasing concentration. However, these values are simulated for formatting purposes and must be replaced with actual experimental measurements before being reported as research findings.

Conclusion

The current work involved the synthesis and screening of anthelmintic activity of pyrazole derivatives of Schiff bases (S1-S10) in vitro using Pheretima posthuma as the test organism. The compounds were screened at 10, 20, and 40 mg/mL, respectively, while Albendazole was used as the reference standard (10 mg/mL). The synthesised Schiff bases were characterised by IR, ^{1}H NMR, and mass spectrometry.

The in vitro evaluation of anthelmintic was done based on the time taken for paralysis and death of earthworms. Of all the synthesised derivatives, S2 appeared to show the best preliminary results in the illustrative data set, with paralysis times of 24, 16, and 10 minutes, and death times of 42, 31, and 22 minutes at concentrations of 10, 20, and 40 mg/mL, respectively. S6 showed comparatively good activity, with paralysis times of 35, 25, and 17 minutes and death times of 61, 46, and 33 minutes at similar concentrations, respectively. S5 showed moderate activity with paralysis times of 43, 31, and 21 minutes and death times of 70, 54, and 39 minutes, respectively. Albendazole, at concentration 10 mg/mL, exhibited a paralysis time of 12 minutes and death time of 25 minutes in the illustrative data set.

Overall, the presented example suggests a concentration-related reduction in paralysis and death times for the synthesised derivatives. However, because these values are simulated rather than experimentally measured, they cannot establish the actual potency or statistical significance of the compounds. Actual laboratory observations and appropriate statistical analysis are necessary to determine their relative anthelmintic activity.

The present work provides a preliminary framework for investigating pyrazole-based Schiff base derivatives as potential anthelmintic candidates. Further studies using experimentally validated results, additional

concentrations, appropriate controls, and suitable biological models are required to establish their efficacy, safety, and potential mechanism of action.

References

1. World Health Organization. Soil-transmitted helminth infections. WHO Fact Sheet; 18 January 2023. https://www.who.int/news-room/fact-sheets/detail/soil-transmitted-helminth-infections
2. World Health Organization. Deworming in children. WHO eLENA; updated 9 August 2023. https://www.who.int/tools/elena/interventions/deworming
3. World Health Organization. Guideline: preventive chemotherapy to control soil-transmitted helminth infections in at-risk population groups. Geneva: WHO; 2017.
4. Razzaghi N, et al. Structural perspective into thiazoles and other azole derivatives as anthelmintic agents. Acta Tropica. 2025. doi:10.1016/j.actatropica.2024.107463.
5. Menezes RA, Bhat KS. Synthetic aspects, structural insights and pharmacological potential of pyrazole derivatives: an overview. Discover Applied Sciences. 2025;7:137. doi:10.1007/s42452-025-06528-x.
6. Jiao Y, Preston S, Song H, Jabbar A, Liu Y, Baell J, et al. Assessing the anthelmintic activity of pyrazole-5-carboxamide derivatives against Haemonchuscontortus. Parasites & Vectors. 2017;10:272. doi:10.1186/s13071-017-2191-8.
7. Rani, Sapna, Salahuddin, Avijit Mazumder, Rajnish Kumar, Saloni Mangal, Vimal Datt, Mohamed Jawed Ahsan, and Mohammad Shahar Yar. "Advances in the synthesis and therapeutic exploration of pyrazole/pyrazoline-bearing benzimidazoles: Searching for new lead compounds." *Current Organic Chemistry* 30, no. 6 (2026): 391-408.
8. Maity, Arindam. "PYRAZOLE AND ITS DERIVATIVES: PREPARATION, SAR AND ANTHELMINTIC ACTIVITY." *Pyrazole: Preparation and Uses* (2020): 471.
9. Kajal A, Bala S, Kamboj S, Sharma N, Saini V. Schiff bases: a versatile pharmacophore. J Catalysts. 2013;2013:893512.
10. Khan Z, Tanoli MAK. Exploring the legacy: the biological interactions of bis Schiff bases and their coordinated azomethine derivatives over time. Pak J Med Dent. 2024;13(2):90-101.
11. Le, Thuy G., Abhijit Kundu, Atanu Ghoshal, Nghi H. Nguyen, Sarah Preston, Yaqing Jiao, Banfeng Ruan et al. "Novel 1-methyl-1 h-pyrazole-5-carboxamide derivatives with potent anthelmintic activity." *Journal of medicinal chemistry* 62, no. 7 (2019): 3367-3380.
12. Milišiūnaitė, Vaida, Alena Kadlecova, Asta Žukauskaitė, Karel Doležal, Miroslav Strnad, Jiří Voller, Eglė Arbačiauskienė, Wolfgang Holzer, and Algirdas Šačkus. "Synthesis and anthelmintic activity of benzopyrano [2, 3-c] pyrazol-4 (2 H)-one derivatives." *Molecular Diversity* 24, no. 4 (2020): 1025-1042.
13. Kumar, Pawan, Rohit Bhatia, and Naresh Kumar Rangra. "Scaffolds imparting anthelmintic activity: recent advancements and SAR studies." *Molecular Diversity* 29, no. 1 (2025): 783-816.
14. Faisal, Muhammad, Aamer Saeed, Sarwat Hussain, Parsa Dar, and Fayaz Ali Larik. "Recent developments in synthetic chemistry and biological activities of pyrazole derivatives." *Journal of Chemical Sciences* 131, no. 8 (2019): 70.
15. Patra, Pratap Kumar, Ch Niranjan Patra, and Subasini Pattnaik. "Antifungal and Anthelmintic Activity of Some Novel Pyrazole Derivative." *Asian Journal of Research in Chemistry* 7, no. 1 (2014): 7.
16. Jiao, Yaqing, Sarah Preston, Hongjian Song, Abdul Jabbar, Yuxiu Liu, Jonathan Baell, Andreas Hofmann et al. "Assessing the anthelmintic activity of pyrazole-5-carboxamide derivatives against Haemonchus contortus." *Parasites & vectors* 10, no. 1 (2017): 272.
17. Jaiswal Shivam ,Gupta K. Sujeet *et al* "Design ,Synthesis,Molecular Docking ,Anti Inflammatory Evaluation of Novel Pyrazole- schiff Base hybride as Potential COX-1 COX-2 Inhibitors" IJDDT , 16,(2026) 71s 176-186.
18. Jacob, K. Sony, and Swastika Ganguly. "Synthesis, anti microbial screening and cytotoxic studies of some novel pyrazole analogs." *Journal of Applied Pharmaceutical Science* 6, no. 11 (2016): 135-141.
19. Morais, Cristiane S., Ana C. Mengarda, Fábio B. Miguel, Karine B. Enes, Vinícius C. Rodrigues, Maria Cristina C. Espírito-Santo, Abolghasem Siyadatpanah, Polrat Wilairatana, Mara RC Couri, and Josué de Moraes. "Pyrazoline derivatives as promising novel antischistosomal agents." *Scientific Reports* 11, no. 1 (2021): 23437.
20. Galli, Giulio, Marta Ruiz-Somacarrera, Laura González del Palacio, Estela Melcón-Fernández, Rubén González-Pérez, Carlos García-Estrada, Maria Martinez-Valladares, and Rafael Balaña-Fouce. "High-throughput screening of five compound libraries for anthelmintic activity and toxicity leads to the discovery of two flavonoid compounds." *International Journal of Molecular Sciences* 26, no. 4 (2025): 1595.
21. Aggarwal, Ranjana, Manisha Sharma, Mona Hooda, Prabodh C. Sharma, and Diksha Sharma. "Eco-friendly Regioselective Synthesis, Biological Evaluation of Some New 5-acylfunctionalized 2-(1H-pyrazol-1-yl) thiazoles as Potential Antimicrobial and Anthelmintic Agents." *ChemistryOpen* 13, no. 11 (2024): e202400142.
22. Alam, Faruk. "Synthesis and biological evaluation of some pyrazole-based Mannich Bases." *Research Journal of Pharmacy and Technology* 12, no. 9 (2019): 4225-4230.
23. HASSAN, ALIH, and HAMID H. MOHAMMED. "Synthesis and biological evaluation of Schiff bases and pyrazole derivatives derive from chalcones,(2E)-1-(4-aminophenyl)-3-(2-furyl) prop-2-en-1-one." *International Journal of Pharmaceutical Research* 12, no. 1 (2020).
24. Singh, Neetu, Sujeet Kumar Gupta, and Lavkush Tiwari. "Current study about pharmacological properties of pyrazole." *Int. J. Pharm. Erud* 11 (2021): 1-21.
25. Pratik, Khanal, Kumar Arun, Srivastava Neha, Yogi Bhumika, Sinha Anshuman, and Gupta S. Kumar. "Synthesis, Characterization of Ethyl 5-(substituted)-1 H-pyrazole-3-carboxylate Derivative as Potent Anti-inflammatory Agents." *Anti-Inflammatory & Anti-Allergy Agents in Medicinal Chemistryrrent Medicinal Chemistry-Anti-Inflammatory and Anti-Allergy Agents)* 17, no. 1 (2018): 32-38.

26. Verma, Ram Sevak, Nitin Mittal, Bhumika Yogi, Sujeet Kumar, Suraj Mishra Gupta, Abhishek Mishra, Shivam Jaiswal, and Aman Kumar Singh. "A Review On Imidazo [2, 1-b] Thiazole Based Heterocyclic Nucleus As Anticancer Properties."