

Antidiarrhoeal Activity of Methanolic Stem Bark Extract of *Anogeissus leiocarpus* in Albino Rats

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Abstract

Diarrhoea remains a major global health concern, especially in developing countries where herbal remedies are commonly used for treatment. This study investigated the antidiarrhoeal activity of the methanol stem bark extract of *Anogeissus leiocarpus* in Wistar albino rats. The antidiarrhoeal effect was evaluated using three models: castor oil-induced diarrhoea, charcoal meal gastrointestinal transit, and castor oil-induced enteropooling. The extract was administered orally at doses of 200, 400, and 800 mg/kg. Loperamide (5 mg/kg) and atropine (3 mg/kg) served as standard drugs, while normal saline served as the negative control. In the castor oil-induced diarrhoea model, the extract produced a significant ($p < 0.05$) and dose-dependent protection of 24.5%, 52.8%, and 59.4% at 200, 400, and 800 mg/kg respectively. The normal saline group had 0% protection, while loperamide produced 90.4% protection. In the charcoal meal test, the extract caused a significant ($p < 0.05$) and dose-dependent reduction in intestinal transit with percentage inhibitions of 19.3%, 35.7%, and 50.2% at 200, 400, and 800 mg/kg respectively, compared to 80.6% inhibition by atropine. In the enteropooling model, the extract also produced a significant ($p < 0.05$) and dose-dependent inhibition of intestinal fluid accumulation of 70.0%, 78.0%, and 85.7% at 200, 400, and 800 mg/kg respectively, compared to 90.6% inhibition by loperamide. The normal saline group had 0% inhibition. These findings suggest that the methanol stem bark extract of *Anogeissus leiocarpus* possesses potent antidiarrhoeal activity via antimotility and antisecretory mechanisms. The results provide scientific support for the traditional use of *Anogeissus leiocarpus* in the management of diarrhoea and related gastrointestinal disorders.

Keywords: antidiarrhoeal activity; *Anogeissus leiocarpus*; castor oil-induced diarrhoea; enteropooling; gastrointestinal transit

1 Introduction

Anogeissus leiocarpus, commonly called African birch or axlewood, is a highly valued medicinal tree widely distributed across the African savanna (Mukhtar *et al.*, 2017). The stem bark is traditionally used to manage diarrhoea, dysentery, stomach ulcers, intestinal worms, wounds, and microbial infections (Adekunle *et al.*, 2024). In Nigeria and other parts of sub-Saharan Africa, the stem bark is often prepared as decoctions or infusions, and it is also commonly used as a chewing stick for oral hygiene due to its antimicrobial properties (Ndukwe *et al.*, 2005; Ior *et al.*, 2014; Akande *et al.*, 2024).

Phytochemical studies have shown that *Anogeissus leiocarpus* is rich in bioactive compounds including flavonoids, tannins, ellagic acid, ellagitannins, triterpenes, alkaloids, and saponins. These constituents have been associated with antibacterial, antifungal, antioxidant, and antidiarrhoeal activities (Orlando *et al.*, 2019; Ene *et al.*, 2021). Several studies support the traditional use of the plant. Methanol and aqueous extracts of *Anogeissus leiocarpus* have demonstrated antimicrobial

activity against pathogens such as *Escherichia coli* and *Shigella dysenteriae*, which are known to cause diarrhoea and other gastrointestinal infections (Olufunke *et al.*, 2022). Furthermore, aqueous stem bark extract produced a significant, dose-dependent inhibition of castor oil-induced diarrhoea in rats, comparable to the standard drug loperamide (Ahmed *et al.*, 2025). The antidiarrhoeal activity is thought to be mediated through multiple mechanisms: tannins precipitate proteins in the intestinal mucosa to reduce secretion, flavonoids inhibit intestinal motility and hydro-electrolytic secretion, while saponins may exert antispasmodic effects (Abdullahi and Ermias, 2025). Despite these reports, most studies have focused on the aqueous and ethanol extracts of the leaves and stem bark. Limited data exist on the methanol stem bark extract and its specific effects on intestinal motility and fluid accumulation (Alemayehu *et al.*, 2023).

The validation of traditional uses through scientific research not only bridges the gap between traditional and modern medicine but also contributes to the search for new, affordable, and effective therapeutic agents from natural sources (Wang *et al.*, 2023). *Anogeissus leiocarpus* has been traditionally employed in various African communities to manage a range of health conditions. The stem bark, in particular, is used to treat diarrhoea, dysentery, wounds, and infections. In Nigeria, it is commonly used as a chewing stick due to its antimicrobial properties, aiding in oral hygiene and preventing dental caries (Namadina *et al.*, 2021). The widespread use of this plant in traditional medicine underscores its therapeutic significance and warrants scientific exploration to validate these traditional claims. Several studies have investigated the antidiarrhoeal properties of *Anogeissus leiocarpus*. Zumbes *et al.* (2007) demonstrated that both aqueous and ethanol leaf extracts exhibited significant antibacterial activity against common diarrhoea-causing bacteria such as *Escherichia coli* and *Salmonella typhi*. The ethanol extract, in particular, showed higher antibacterial activity, suggesting its potential effectiveness in managing bacterial diarrhoea. In another study, the aqueous stem bark extract of *Anogeissus leiocarpus* produced a significant, dose-dependent inhibition of castor oil-induced diarrhoea in rats, an effect comparable to the standard antidiarrhoeal drug, loperamide. These findings support the traditional use of *Anogeissus leiocarpus* in treating diarrhoea and highlight its potential as a natural antidiarrhoeal agent.

The antidiarrhoeal effects of *Anogeissus leiocarpus* have been attributed to its phytochemical constituents. Tannins precipitate proteins in the intestinal mucosa, thereby reducing secretion and making the lining more resistant to chemical irritation. Flavonoids inhibit intestinal motility and hydro-electrolytic secretion, while saponins may exert antispasmodic effects on the gastrointestinal tract (Ambair *et al.*, 2025). These combined actions contribute to the plant's effectiveness in managing diarrhoea.

2 Materials and methods

2.1 Materials

- Equipment: plastic rodent cages, surgical gloves, face masks, 1 mL and 2 mL syringes, beakers and surgical blades.
- Instruments: analytical weighing balance.
- Chemicals and drugs: distilled water (Dona Nig. Ltd, Nigeria), castor oil (Bellsons and Co. Ltd, England), activated charcoal 5% w/v (Kochlight Laboratories Ltd, England), loperamide 5 mg (RPG Life Science Ltd, Ankleshwar, India) and atropine (Fujisawa USA Inc.).

2.2 Sample collection and identification

Fresh stem bark of *Anogeissus leiocarpus* was collected from Molai, Maiduguri, Borno State, Nigeria. The plant was authenticated by a plant taxonomist at the Department of Biological Sciences, University of Maiduguri, and a voucher specimen was deposited at the University Herbarium with voucher number CM345. The stem bark was air-dried under shade for two weeks until a constant weight was obtained. It was then rendered free of foreign materials by manual sorting and pulverized using a wooden mortar and pestle to obtain a fine powder. The powdered material was stored in an airtight container at room temperature until further use.

2.3 Plant extraction

Two hundred grams (200 g) of the pulverized dried stem bark of *Anogeissus leiocarpus* was subjected to cold extraction by maceration. The powdered material was soaked in 2.5 L of absolute methanol at room temperature for 72 h in a round-bottom flask with occasional shaking. After 72 h, the mixture was first sieved through muslin cloth to remove coarse debris and then filtered through Whatman No. 1 filter paper. The filtrate was concentrated to dryness using a rotary evaporator. The crude extract obtained was weighed, labelled, and stored at 4°C until used for antidiarrhoeal analysis.

2.4 Animals

Seventy-five Wistar albino rats weighing between 80–150 g were obtained from Jos, Plateau State, Nigeria. The animals were housed in plastic rat cages and allowed to acclimatize to the laboratory environment for a minimum period of two weeks before the commencement of the experiments. They were fed grower's mash (Vital Feed Nig. Ltd., Jos, Nigeria) and given water *ad libitum*. All experimental procedures were conducted in compliance with the international guiding principles for biomedical research involving animals (CIOMS and ICLAS, 2012).

2.5 Effect of the methanol stem bark extract of *Anogeissus leiocarpus* on castor oil-induced diarrhoea

The method of Williamson *et al.* (1996) was adopted to evaluate the effect of the methanol stem extract on castor oil-induced diarrhoea. Twenty-five Wistar albino rats of both sexes, weighing 80–150 g, were used for the study. The animals were deprived of food for 12 h but had free access to water *ad libitum*. The rats were randomly divided into five groups of five rats each. Groups B, C, and D were administered the extract orally at doses of 200, 400, and 800 mg/kg, respectively. Group A was administered 2 mL of distilled water orally and served as the negative control. Group E was administered 5 mg/kg of loperamide intraperitoneally and served as the standard drug group. The rats were housed individually in cages lined with white blotting paper. One hour after treatment, diarrhoea was induced in all rats by oral administration of 1 mL of castor oil. The animals were observed for 6 h and the number of wet and watery faecal droppings was counted and recorded for each rat. The percentage protection against diarrhoea was calculated using the formula of Nwafor *et al.* (2001):

$$\%Protection = \frac{\text{Mean defecation of control} - \text{Mean defecation of treated group}}{\text{Mean defecation of control}} \times 100 \quad (1)$$

2.6 Effect of the methanol stem bark extract of *Anogeissus leiocarpus* on gastrointestinal transit of charcoal meal

The method of Williamson *et al.* (1996) as adopted by Dawa (2022) was used to study the effect of the methanol extract of *Anogeissus leiocarpus* on gastrointestinal transit of charcoal meal in rats. Twenty-five (25) albino rats weighing 80–150 g were used for this experiment. The rats were deprived of food for 18 h but were allowed free access to water *ad libitum*. They were divided into five groups of five rats each. Group A served as the control and was given 2 mL of distilled water orally. Rats in Groups B, C, and D were administered 200, 400, and 800 mg/kg of the methanol extract orally, respectively. Group E rats were treated with 3 mg/kg atropine (Fujisawa U.S.A. Inc.) intraperitoneally as the standard drug. After 10 minutes, 1 mL of charcoal meal [5% activated charcoal suspension in 10% acacia powder solution] was administered orally to each rat. Thirty minutes later, the rats were sacrificed and the abdomen was opened. The distance travelled by the charcoal meal was measured and expressed as a percentage of the total length of the small intestine. The percentage intestinal transit of the charcoal meal was calculated using the formula:

$$\%Intestinaltransit = \frac{\text{Distance moved by charcoal meal (cm)}}{\text{Total length of small intestine (cm)}} \times 100 \quad (2)$$

A decrease in gastrointestinal propulsion of the charcoal meal indicates an antidiarrhoeal effect, whereas an increase in gastrointestinal propulsion indicates a laxative effect.

2.7 Effect of the methanol stem bark extract of *Anogeissus leiocarpus* on castor oil-induced enteropooling

All experimental procedures were conducted in accordance with the international guiding principles for biomedical research involving animals and were approved by the University Animal Ethics Committee. The method of Robert *et al.* (1976) was used to evaluate the effect of the methanol stem bark extract on intraluminal fluid accumulation in rats. Twenty-five (25) Wistar albino rats of both sexes weighing 80–150 g were used for this experiment. The rats were fasted overnight but were allowed free access to water *ad libitum*. They were then divided into five groups of five rats each. Group A served as the negative control and was administered 2 mL of distilled water orally. Groups B, C, and D were administered 200, 400, and 800 mg/kg of the extract orally, respectively. Group E was administered 5 mg/kg loperamide intraperitoneally and served as the standard drug group. One hour after treatment, all the rats were sacrificed and the small intestine was excised and weighed. The intestinal content was expelled by milking, and the weights of the empty intestine and the intestinal content were recorded.

2.8 Statistical analysis

Data are presented as mean $\pm$ standard deviation (SD). One-way analysis of variance (ANOVA) was used to test for significance, and $p < 0.05$ was considered significant.

3 Results

3.1 Effect of the extract of *Anogeissus leiocarpus* on castor oil-induced diarrhoea in rats

The effect of the extract on castor oil-induced diarrhoea is shown in Table 1.

Table 1. Effect of the methanol stem bark extract of *Anogeissus leiocarpus* on castor oil-induced diarrhoea in rats.

Group	Extract/drug	Total no. of wet faeces in 6 h	Protection (%)
A	Normal saline	7.80 ± 0.00 ^a	0.0
B	200 mg/kg	3.80 ± 0.03 ^{bc}	24.5
C	400 mg/kg	3.40 ± 0.05 ^{cd}	52.8
D	800 mg/kg	3.00 ± 0.00 ^{de}	59.4
E	Loperamide (5 mg/kg)	0.60 ± 0.03 ^e	90.4

Means with different superscript letters are significantly different from each other ($p < 0.05$).

The results showed that the methanol extract of *Anogeissus leiocarpus* produced a dose-dependent antidiarrhoeal effect in rats. The negative control group treated with distilled water had the highest number of wet faeces (7.80), confirming successful induction of diarrhoea by castor oil. Administration of the extract at 200 mg/kg produced a moderate reduction in diarrhoeal output (3.80 wet faeces) with 24.5% protection. Increasing the dose to 400 mg/kg further reduced the number of wet faeces to 3.40, corresponding to 52.8% protection, indicating improved antidiarrhoeal activity. The highest dose, 800 mg/kg, produced the strongest effect among the extract-treated groups, with 3.00 wet faeces and 59.4% protection, demonstrating that the antidiarrhoeal activity of the extract increased with dose. The standard drug, loperamide (5 mg/kg), exhibited the highest level of protection (90.4%) and produced the lowest number of wet faeces (0.60), as expected for a clinically effective antidiarrhoeal agent. Compared to the standard drug, the plant extract exhibited significant but lower antidiarrhoeal potency.

3.2 Effect of the extract of *Anogeissus leiocarpus* on gastrointestinal transit of charcoal meal in rats

The effect of the extract on gastrointestinal transit of charcoal meal is shown in Table 2.

Table 2. Effect of the methanol stem bark extract of *Anogeissus leiocarpus* on gastrointestinal transit of charcoal meal in rats.

Group	Extract/drug dose	Total length of intestine (cm)	Movement of charcoal (cm)	Intestinal transit (%)	Inhibition (%)
A	Normal saline	24.43 ± 0.00 ^a	20.77 ± 0.00	84.9	0.00
B	200 mg/kg	24.43 ± 0.00 ^a	16.67 ± 0.00 ^{cdef}	68.2	19.3
C	400 mg/kg	24.53 ± 0.05 ^a	13.33 ± 0.00 ^{def}	54.3	35.7
D	800 mg/kg	22.33 ± 0.00 ^a	10.33 ± 0.00 ^{ef}	46.2	50.2
E	Atropine (3 mg/kg)	20.20 ± 0.00 ^a	4.00 ± 0.00 ^e	20.2	80.6

Means with the same superscript letter are not significantly different ($p > 0.05$); means with different letters are significantly different from each other ($p < 0.05$).

Administration of the methanol stem bark extract of *Anogeissus leiocarpus* caused a dose-dependent reduction in gastrointestinal transit of charcoal meal in rats. The control group showed 84.9% intestinal transit, whereas the extract-treated groups at 200, 400, and 800 mg/kg recorded 68.2%, 54.3%, and 46.2% transit, corresponding to 19.3%, 35.7%, and 50.2% inhibition, respectively. The standard drug, atropine (3 mg/kg), produced the highest inhibition (80.6%). Statistical analysis

revealed that all treatment groups significantly ($p < 0.05$) reduced intestinal transit compared to the control, while differences in total intestinal length were not significant among groups.

3.3 Effect of *Anogeissus leiocarpus* on castor oil-induced enteropooling in rats

The effect of the extract on castor oil-induced enteropooling is shown in Table 3.

Table 3. Effect of the methanol stem bark extract of *Anogeissus leiocarpus* on castor oil-induced enteropooling in rats.

Group	Extract/drug dose	Weight of intestine with content (g)	Weight of empty intestine (g)	Weight of content (g)	Fluid accumulation (%)	Inhibition (%)
A	Normal saline	7.07 ± 3.67	0.29 ± 3.32 ^b	1.66 ± 4.51 ^{bc}	51.0	0.00
B	200 mg/kg	3.63 ± 0.51 ^a	2.38 ± 0.02 ^b	1.10 ± 0.47 ^{cd}	30.1	70.0
C	400 mg/kg	3.59 ± 0.61 ^a	3.10 ± 0.46 ^b	0.64 ± 0.92 ^{dc}	22.2	78.0
D	800 mg/kg	2.99 ± 0.46 ^a	2.27 ± 0.49 ^b	0.42 ± 0.14 ^{ef}	14.4	85.7
E	Atropine (3 mg/kg)	3.26 ± 0.65 ^a	2.84 ± 0.74 ^b	0.31 ± 0.11 ^f	10.4	90.6

Means with the same superscript letter are not significantly different ($p > 0.05$); means with different letters are significantly different from each other ($p < 0.05$).

The effect of *Anogeissus leiocarpus* on castor oil-induced enteropooling showed a progressive reduction in intestinal fluid accumulation, indicating dose-dependent ant motility and antisecretory activity. In the negative control group treated with distilled water, the intestinal fluid content was highest at 51.0% with 0% inhibition, confirming that castor oil successfully induced excessive fluid secretion in the intestine. Treatment with 200 mg/kg of the extract produced a noticeable decrease in fluid accumulation, reducing the percentage fluid to 30.1% and achieving 70.0% inhibition, suggesting a mild antisecretory effect at the lower dose. A more pronounced effect was observed at 400 mg/kg, where intestinal fluid content dropped to 22.2% with 78.0% inhibition, demonstrating that intermediate doses more effectively counteracted castor oil's secretory action. The highest dose, 800 mg/kg, further reduced fluid content to 14.4% and produced 85.7% inhibition, indicating a strong dose-response relationship. This reduction suggests that the extract may inhibit prostaglandin-mediated secretion or enhance fluid absorption. Although the extract showed substantial activity, the standard drug, atropine (3 mg/kg), produced the greatest inhibition (90.6%) and the lowest fluid content (10.4%), validating the experimental model and demonstrating superior efficacy. Overall, the findings suggest that *Anogeissus leiocarpus* possesses significant antisecretory effects, supporting its antidiarrhoeal potential. However, its activity was lower than that of atropine, indicating the need for further studies to isolate active compounds, clarify mechanisms of action, and optimize dosage.

4 Discussion

Diarrhoea is defined as the passage of loose or watery stools more frequently than is normal for an individual. It is not a disease in itself, but a sign of several underlying conditions. It may be associated with abdominal pain, which often reduces after passage of stool. Diarrhoea occurs due to irritation of the lining of the small or large intestine, leading to decreased water absorption and increased water content in the faeces. Castor oil is known to induce diarrhoea by increasing the volume of intestinal contents, inhibiting reabsorption of water and electrolytes, and stimulating intestinal motility. In this

study, the methanol stem bark extract of *Anogeissus leiocarpus* at doses of 200, 400, and 800 mg/kg significantly decreased ($p < 0.05$) the total number of wet faeces produced following castor oil administration. The effect at 800 mg/kg was comparable to the standard drug, loperamide. This suggests that the antidiarrhoeal action of the extract may be mediated via an antisecretory mechanism. The extract also significantly ($p < 0.05$) decreased the propulsion of charcoal meal through the gastrointestinal tract at all tested doses compared to the control group. The effect at the highest dose was similar to that of the standard drug, atropine. This indicates that the extract reduced diarrhoea by inhibiting gastrointestinal motility and peristalsis. Furthermore, the significant inhibition of castor oil-induced enteropooling by the extract suggests an antisecretory and anti-enteropooling effect. Taken together, these observations suggest that the methanol stem bark extract of *Anogeissus leiocarpus* produced relief from diarrhoea through both spasmolytic and antisecretory mechanisms *in vivo*. The findings of this study therefore provide scientific support for the traditional use of *Anogeissus leiocarpus* in the prevention and management of diarrhoea and related gastrointestinal disorders.

5 Conclusion

The findings of this study demonstrate that the methanol stem bark extract of *Anogeissus leiocarpus* possesses significant antidiarrhoeal activity in Wistar albino rats. The extract produced dose-dependent protection against castor oil-induced diarrhoea, inhibited gastrointestinal motility in the charcoal meal test, and reduced castor oil-induced enteropooling. The effects observed at 800 mg/kg were comparable to those of the standard drugs, loperamide and atropine. These activities may be attributed to the presence of phytochemicals such as tannins, flavonoids, and saponins, which are known to exert antisecretory, antimotility, and spasmolytic effects. The results therefore provide scientific validation for the traditional use of *Anogeissus leiocarpus* stem bark in the management of diarrhoea and other gastrointestinal disorders.

5.1 Recommendations

Based on the findings of this study, the following are recommended:

1. Further studies should be carried out to isolate and characterize the specific bioactive compounds responsible for the antidiarrhoeal activity of *Anogeissus leiocarpus*.
2. Toxicity studies, including acute and sub-chronic toxicity, should be conducted to establish the safety profile of the extract for possible therapeutic use.
3. Clinical trials are suggested to evaluate the efficacy and safety of the extract in humans, which could lead to the development of a standardized herbal antidiarrhoeal drug.
4. Public enlightenment on the proper preparation and dosage of *Anogeissus leiocarpus* should be encouraged to promote its safe use in traditional medicine.

Conflict of interest

The authors declare no conflict of interest.

References

- [1] Abdullahi ION, Ermias MT (2025). Evaluation of the antidiarrhoeal activity of dichloromethane–methanol crude extract of the aerial parts of *Croton kinondoensis* (Euphorbiaceae) in mice. *Evidence-Based Complementary and Alternative Medicine*, 20(10).
- [2] Adekunle YA, Samuel BB, Nahar L, Fatokun AA, Sarker SD (2024). *Anogeissus leiocarpus* (DC.) Guill. & Perr. (Combretaceae): A review of the traditional uses, phytochemistry and pharmacology of African birch. *Fitoterapia*, 176, 105979. <https://doi.org/10.1016/j.fitote.2024.105979>
- [3] Ahmed MU, Comfort E, Adamu YM (2025). Evaluation of the antidiarrhoeal activity of aqueous stem bark extract of *Anogeissus leiocarpus* on castor oil-induced diarrhoea in rats. *African Journal of Medicine, Surgery and Public Health Research*, 2(1), 14–24.
- [4] Akande FA, Lawal MO, Ogunbi GA (2024). Therapeutic potentials of African birch: A comprehensive review. *Journal of Medicinal Plant Studies*, 18(1), 33–45.
- [5] Alemayehu M, Beyene D, Meaza A, Kefyalewa AG, Eshetie MB (2023). Evaluation of antidiarrhoeal activities of the 80% methanol extract and solvent fractions of *Maesa lanceolata* Forssk (Myrsinaceae) leaves in mice. *Journal of Experimental Pharmacology*, 15, 391–405. <https://doi.org/10.2147/JEPS429403>
- [6] Ambair HL, et al. (2025). Comparative phytochemical profiling of African herbal remedies. *Journal of Herbal Pharmacology*, 14(1), 50–62.
- [7] CIOMS and ICLAS (2012). International guiding principles for biomedical research involving animals. *Council for International Organizations of Medical Sciences and the International Council for Laboratory Animal Science*. iclas.org/wp-content/uploads/2013/03/CIOMS-ICLAS-Principles-Final1.pdf
- [8] Dawa SI, Nkafamiya II, Shagal MH, Mamza UT, Yakubu J (2022). Antidiarrhoeal effects of methanol root extract of *Detarium microcarpum* (Leguminosae) in albino rats. *Bulletin of Pure and Applied Sciences – Chemistry*, 41C(1), 22–28.
- [9] Ene AC, Ajayi IA, Abubakar MS (2021). Phytochemical and antimicrobial potentials of *Anogeissus leiocarpus*. *West African Journal of Pharmacognosy*, 12(2), 45–53.
- [10] Ior LD, Anyam JV, Tyoakaa AT (2014). Ethnomedicinal uses of *Anogeissus leiocarpus* in rural communities. *Journal of Medicinal Plant Research*, 8(15), 646–654.
- [11] Mukhtar Y, Abdu K, Maigari AK (2017). Efficacy of *Anogeissus leiocarpus* as potential therapeutic agent against trypanosomiasis diseases. *International Journal of Health and Pharmaceutical Research*, 3(3).
- [12] Namadina MM, Ahmed MS, Garba H (2021). Antimicrobial properties of chewing sticks from *Anogeissus leiocarpus*. *Journal of Oral Microbiology*, 13(2), 85–94.
- [13] Ndukwe IG, et al. (2005). Ethnobotanical survey of medicinal plants in northern Nigeria. *Nigerian Journal of Botany*, 18(2), 45–54.
- [14] Olufunke AA, et al. (2022). Antibacterial effects of selected Nigerian medicinal plants. *Journal of Applied Medical Sciences*, 10(1), 33–41.
- [15] Orlando L, et al. (2019). Phytochemical review of *Anogeissus leiocarpus*. *Journal of Medicinal Plant Biochemistry*, 9(2), 88–97.
- [16] Robert A, Nezamis JE, Lancaster C, Hanchar AJ, Klepper MS (1976). Enteropooling assay: A test for diarrhea produced by prostaglandins. *Prostaglandins*, 11(5), 809–828.
- [17] Wang H, Chen Y, Wang L, Liu Q, Yang S, Wang C (2023). Advancing herbal medicine: Enhancing product quality and safety through robust quality control practices. *Frontiers in Pharmacology*, 14, 1265178. <https://doi.org/10.3389/fphar.2023.1265178>
- [18] Williamson EM, Okpako DT, Evans FJ (1996). Pharmacological methods in phytotherapy research. *Chichester: Wiley*.
- [19] Zumbes HJ, et al. (2007). Antibacterial activity of leaf extracts of *Anogeissus leiocarpus*. *Nigerian Journal of Microbiology*, 21(1), 149–158.