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In vitro anthelmintic effects of hydromethanolic extracts of *Ricinus communis* (Euphorbiaceae) on *Haemonchus contortus* Rudolphi, 1803, a nematode parasite of small ruminants

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***Abstract*---Background:** With the aim of contributing to animal production through the reduction of the prevalence of haemonchosis, a study based on the *in vitro* anthelmintic effects of hydromethanolic extracts of *Ricinus communis* on *Haemonchus contortus* was conducted in Ngaoundere, Cameroon. **Materials and Methods:** Extracts obtained by maceration of 50 g of *Ricinus communis* leaf powder in methanol. Various chemical compounds were identified using standard colorimetric methods. *In vitro* inhibition of *Haemonchus contortus* egg hatching was performed and anthelmintic activity of the hydromethanolic extract of *Ricinus communis* leaves was evaluated according to the standard protocol. The acute toxicity test of *Ricinus communis* extract was conducted following the method of OECD Guideline. **Results:** Qualitative phytochemical characterization revealed that the hydromethanolic extract of this plant's leaves is rich in chemical compounds. Quantitative analyses showed a high tannin content, remarkable amounts of phenolic compounds, and flavonoids. The egg hatching inhibition test and various assays on larvae and adults revealed that the hydromethanolic extract of *R. communis* leaves possesses genuine anthelmintic effects. In larvae, paralysis rates varied with concentrations and incubation time. In adults, the hydromethanolic extract of *Ricinus communis* proved effective. Acute toxicity performed on female *Mus musculus* at a single dose showed no abnormal clinical signs or mortality during the 14-day observation period. **Conclusion:** The hydromethanolic extract of *R. communis* demonstrated interesting anthelmintic activity and was shown to be non-toxic in mice.

Keywords*---*Haemonchus contortus, Anthelmintic, Hydromethanolic extract, *Ricinus communis*.

1. INTRODUCTION

Worldwide, small ruminants — particularly goats — occupy an important place in animal production, significantly contributing to nutrition, food security, and the overall economy of many developing countries (Lu, 2023). These animals play a major role within rural families through the income they generate from milk, meat, hides, and wool (Lateef *et al.*, 2005). Unfortunately, small ruminants raised primarily on pasture are exposed to infestation by gastrointestinal nematodes

(GIN), particularly haemonchosis, a disease caused by the parasite *Haemonchus contortus*, which constitutes a major cause of morbidity and mortality, leading to substantial economic losses in livestock farming (Ceriac, 2018). Gastrointestinal strongylososes remain the globally dominant pathology in the grazing husbandry of small ruminants (Sabater, 2012). In view of the threats posed by *Haemonchosis*, control measures have been recommended to manage and eliminate the disease. Control of this parasitic disease has long relied on the use of synthetic anthelmintics, including benzimidazoles, probenzimidazoles, imidazothiazoles, and macrocyclic lactones (Qintin and Frank, 2004; Dedehou *et al.*, 2014). These chemical substances represent 35–65% of drug expenditure for livestock animals (Grosmond, 2012). However, several problems have arisen regarding their use. Indeed, the excessive use of anthelmintic products has led to the emergence of resistance worldwide (Coles *et al.*, 2006). In some regions of the world, parasites of *H. contortus* are now resistant to all known classes of anthelmintics. This underscores the urgent need to turn to locally available, biodegradable plant-based resources known to local populations — a viable palliative solution (Mangambu *et al.*, 2012). *Ricinus communis* is a plant of the Euphorbiaceae family, originating from northeastern Africa and the Middle East (Ghnimi, 2015). It possesses antioxidant, anti-inflammatory, antidiabetic, centrally analgesic, antitumor, antifungal, anti-yeast, antinociceptive, and antiasthmatic properties (Manpreet *et al.*, 2012). The present work therefore aims to improve animal production through the reduction of *Haemonchosis contortus* prevalence by using hydromethanolic extracts of *Ricinus communis*.

2. MATERIALS AND METHODS

2.1. Collection and Identification of Plant Material

The plant material consisted of leaves of *Ricinus communis* harvested in Maroua, in the Far-North region of Cameroon, specifically in Meskine (Latitude N10°33'19.17612''; Longitude E14°15'42.48612''; altitude 420 m). Reference specimens were identified by Professor MAPONGMETSEM, a botanist in the Department of Biological Sciences, Faculty of Sciences, University of Ngaoundéré. A reference specimen was subsequently deposited at the National Herbarium of Cameroon/Yaoundé under identification number 9384 from Herbarium Collection No. 42570 SRF/Cam.

2.2. Preparation of the Hydromethanolic Extract

Extraction was carried out by maceration of the plant material. Fifty grams (50 g) of *Ricinus communis* leaf powder were macerated in 500 mL of methanol diluted with distilled water (70:30, v/v) for 48 hours at room temperature. Throughout maceration, the mixture was periodically stirred using a magnetic stirrer, before being centrifuged (Centrifuge 5804-Eppendorf) at 3500 rpm for 10 minutes. The collected supernatant was filtered using filter papers No. 413 (VWR International, Darmstadt, Germany), and the filtrate was subsequently concentrated under reduced pressure (100 mbar) using a rotary evaporator (BUCHI Rotavapor R-200, Switzerland) at 40°C. The resulting solution was placed in a drying oven (40°C) for complete evaporation. The crude extract was obtained by dissolving the evaporation residue in dimethylsulfoxide (100% DMSO), then in distilled water, to a final concentration of 100 mg/mL.

2.3. Phytochemical Analysis

2.3.1. Qualitative Phytochemical Screening

Various chemical compounds were identified using standard colorimetric and precipitation methods (Trease and Evans, 2002). The main groups of compounds investigated were: phenolic compounds, tannins, flavonoids, saponins, alkaloids, steroids, terpenoids, deoxysugars, coumarins, and anthraquinones.

2.3.2. Quantitative Phytochemical Analysis

The purpose of quantitative testing was to determine the chemical compound content of the hydromethanolic extracts of *R. communis* leaves. Only phenolic compounds, condensed tannins, and flavonoids were measured using the following methods:

Total polyphenols were quantified using the Folin-Ciocalteu (FC) method (Boizot and Charpentier, 2006). Absorbance was measured at 760 nm using a UV spectrophotometer (Bioware Cambridge, England). Results are expressed in mg gallic acid equivalent per gram of dry plant matter (mg GAE/g DM) based on a gallic acid calibration curve.

Condensed tannins were determined by the vanillin-acid method described by Ba *et al.* (2010). Absorbance was measured at 500 nm using a UV spectrophotometer (Bioware Cambridge, England) against a blank consisting of equal volumes of methanol (37%) and HCl (8%). Results are expressed in mg catechol equivalent per gram of dry plant matter (mg CE/g DM) based on a catechol calibration curve.

Flavonoid quantification in the extracts was carried out using the aluminum trichloride ($AlCl_3$) method following the protocol of Bahorun *et al.* (1996). Absorbances were measured at 430 nm using a spectrophotometer. All manipulations were repeated 3 times to minimize errors. Under the same conditions, a rutin calibration curve (0–40 µg/mL) was established. Results are expressed in mg rutin equivalent per gram of extract (mg RE/g).

2.4. Collection of Experimental Units

2.4.1. Collection of *Haemonchus contortus* Eggs

Haemonchu contortus eggs were obtained according to the method described by Adamou *et al.* (2021). After isolating the worms using forceps, they were rinsed successively in several Petri dishes containing phosphate-buffered saline (PBS). Gravid female worms were then identified under a binocular magnifier, isolated, and placed 5 per well in a 24-well plate containing 500 µL of PBS. Six hours after incubation, a large quantity of eggs had settled to the bottom of the wells.

After verifying egg presence under a binocular magnifier, the female worms were removed from PBS and the contents were pipetted to concentrate the eggs in a 50 mL Eppendorf tube. Centrifugation at 1000 rpm for 5 minutes was performed. The supernatant was removed, and the egg-containing pellet was stored in an oven at 27°C for 24 h prior to testing.

2.4.2. Egg Hatching Inhibition Test

In vitro inhibition of *Haemonchus contortus* egg hatching was performed using the method described by Coles *et al.* (1992). Eggs of *H. contortus* were incubated with different plant extract concentrations (0.5; 1; 1.5; 2; 2.5; and 3 mg/mL), with 30 eggs per concentration in 24-well plastic culture plates. The positive control (levamisole) and the negative control (PBS) were used at the same concentrations as the plant extracts. Plates were covered and incubated at 37°C for 48 hours.

After incubation, three drops of 10% formalin were added to each well to halt egg development. Stage I larvae (L_1) that hatched were counted using a binocular microscope at ×40 magnification. Each test was repeated 3 times to minimize errors. The percentage egg hatching inhibition (% EHI) was calculated using the formula:

% EHI = 100 − (Number of L_1 larvae / Number of fresh eggs in culture) × 100 (Coles *et al.*, 1992).

2.4.3. Collection of Infective *Haemonchus contortus* Larvae

Haemonchus contortus infective larvae were harvested by coproculture from eggs obtained by incubation (37°C) of gravid females. The eggs were mixed with 20 g of sterile manure (freed of gastrointestinal parasites by oven sterilization at 90°C) and placed in an oven at an optimal temperature of 27°C. After 7–10 days of incubation, eggs hatched and released L_1, L_2, then L_3 larvae, which were concentrated using a Baermann apparatus. This device extracts living nematode larvae by positive hydrotropism and negative phototropism, causing them to migrate toward a water-filled funnel (Okombe, 2011).

2.4.4. Assay on Infective *Haemonchus contortus* Larvae

Twenty-five (25) L_3 larvae of *H. contortus* were pipetted under a binocular magnifier (×40) using a 100 µL micropipette into each well of a 24-well plate and incubated with different concentrations (0.5; 1; 1.5; 2; 2.5; and 3 mg/mL) of the hydromethanolic extract of *R. communis*. Levamisole served as the positive control and PBS as the negative control at the same concentrations. Plates were covered and kept at 27°C for 24 and 48 h. After incubation, 10 µL of the enzymatic dye Methyl-Thiazolyl-Tetrazolium (MTT) at 100% was added to the larvae for 3 hours. MTT triggers enzymatic reactions that stain living larvae blue-violet, while dead larvae remain colorless. Paralyzed larvae (appearing coiled) were counted. Larval mortality percentage was determined using the formula:

MT (%) = (Number of dead larvae / Number of larvae in culture) × 100 (Abbott, 1925).

2.4.5. Collection of Adult Female *Haemonchus contortus* Worms

Adult *H. contortus* worms were obtained using the method of Kaboré (2009) from the abomasum of goats and/or sheep slaughtered at the Bantaille abattoir in Ngaoundéré (Cameroon), then transported to the Applied Zoology Laboratory of the University of Ngaoundéré. Upon arrival, the abomasa, previously delimited by double ligatures, were opened longitudinally, their contents carefully examined, and visible worms were collected using forceps or mounted needles and placed in several Petri dishes containing PBS. Collected worms were examined under a binocular magnifier (×40) to identify adult female *H. contortus* recognized by the presence of a vulvar flap.

2.4.6. In vitro Evaluation of Anthelmintic Effects of the Plant Hydromethanolic Extract on Adult Female *Haemonchus contortus* Worms

The anthelmintic activity of the hydromethanolic extract of *Ricinus communis* leaves was evaluated according to the protocol described by Borsboom *et al.* (2003). Worms were incubated in the presence of different concentrations (0.25; 0.5; 0.75; 1; 1.25; and 1.5 mg/mL) of the hydromethanolic extract of *R. communis* leaves prepared in PBS. Worms were placed one per well in 500 µL of plant extract

— i.e., 3 columns of 6 wells from a 24-well plate per concentration. PBS served as the negative control and levamisole as the positive control at the same concentrations as the extract. Incubations were performed at 37°C, and worm mortality was assessed 24 h later under a stereomicroscope (×20) (Ndjonka *et al.*, 2011). Mortality rate was calculated as:

Mortality rate (%) = (Total number of dead worms / Total number of incubated worms) × 100 (Borsboom *et al.*, 2003).

2.5. Acute Oral Toxicity Assessment

The acute toxicity test of *Ricinus communis* extract was conducted following the "dose adjustment" method of OECD Guideline 425 (2022). Six (06) female Swiss strain *Mus musculus* mice with body weights between 20 and 31 g were fasted for 15 hours before administration, then divided as follows:

- A control group of 3 mice receiving distilled water at 10 mL/kg;
- An experimental group of 3 mice receiving the extract at a dose of 2000 mg/kg body weight (b.w.).

Mice were observed individually during the first 30 minutes and regularly during the first 24 hours post-administration. Particular attention was paid during the first 4 hours, then daily for 14 days. Throughout this period, water and food were provided *ad libitum*, and signs of toxicity — including weight, grooming, respiration, sensitivity to noise after a metallic shock, stool appearance, motility, occurrence of convulsions, and deaths — were recorded.

2.6. Statistical Analysis

Means, standard deviations, and graphs were obtained using Excel 2013. LC_{50} and IC_{50} values were determined by the log-probit method using SPSS 16.0 software. Dunnett's test was used for mean comparisons. Differences between means were considered significant at $P< 0.05$.

3. RESULTS AND DISCUSSION

3.1. Qualitative Phytochemical Screening

Phytochemical analysis of the hydromethanolic extract of *R. communis* leaves revealed the presence of alkaloids, flavonoids, phenolic compounds, steroids, and tannins (Table 1). These results are consistent with those of Ghnimi (2015), who demonstrated the presence of these same compounds in the hydromethanolic extract of R. communis leaves. The same results were reported by Kalmobé *et al.* (2017) using an ethanolic extract of *Cucurbita pepo ovifera* var. ovifera leaves. These authors also noted the absence of flavonoids, triterpenes, and steroids in the seeds, suggesting a strong affinity of these compounds for polar solvents.

Table 1: Phytochemical screening of hydromethanolic extracts of *Ricinus communis* leaves

SM	Alk	Fla	Tan	Sap	Phe.com	Ste	Ter	Anthra	Deo	Gly	Antho
HMEFRc	+	+	+	-	+	+	-	-	-	-	-

SM: Secondary Metabolites; *HMEFRc*: Hydromethanolic extract of *R. communis* leaves; +: present; −: absent; **Alk**: Alkaloids; **Fla**: Flavonoids; **Tan**: Tannins; **Sap**: Saponins; **Phe.com**: Phenolic compounds; **Ste**: Steroids; **Ter**: Terpenoids; **Anthra**: Anthraquinones; **Deo**: Deoxysugars; **Gly**: Glycosides; **Antho**: Anthocyanins

3.2. Quantitative Phytochemical Screening

Quantitative analysis (Figure 1) revealed a high tannin content (530.23 ± 7.23 mg RE/g DM) compared to phenolic compounds (516.23 ± 10.96 mg GAE/g DM) and flavonoids (325.41 ± 3.80 mg CE/g DM). However, these results differ from those obtained by Ghnimi (2015) in Tunisia, who reported relatively lower values for phenolic compounds (174.25 mg GAE/g DM), flavonoids (99.6 mg GAE/g DM), and tannins (0.99 mg CE/g DM) in the hydromethanolic extract of *R. communis* leaves. The differences observed here may be explained by variation in harvest period between studies and in collection location. It is well established that climate and other geographical conditions influence the physicochemical composition of soil and the availability of nutritional elements, which play an important role in the growth of different plant parts. Moreover, leaf drying methods and extraction time can also influence phenolic compound contents (Naczy and Shahidi, 2004).

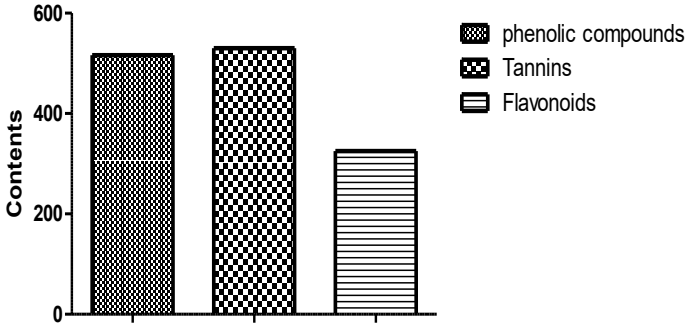
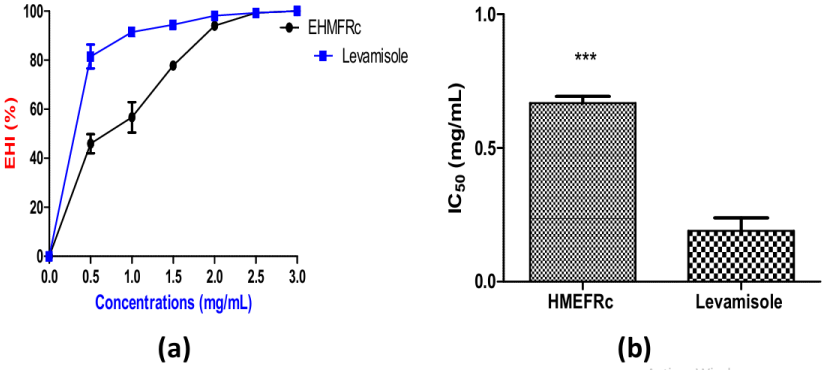


Figure 1: Diagram of secondary metabolite contents of *Ricinus communis* leaves.

3.3. Anthelmintic Activity of Hydromethanolic Extracts of *Ricinus communis*

3.3.1. Ovicidal Activity

Figure 2a presents the effect of the hydromethanolic extract of *R. communis* and levamisole on egg hatching. The egg hatching inhibition rate ranged from 45.93% ± 6.7 to 100% ± 0 for the extract, and from 81.48% ± 8.48 to 100% ± 0 for levamisole. The inhibition rate with the negative control (PBS) was 0%, confirming that PBS had no influence on the eggs. A highly significant difference ($P< 0.001$) was observed between levamisole activity (IC_{50}: 0.19 ± 0.08) and that of the plant extract (IC_{50}: 0.68 ± 0.05) (Figure 2b). The ovicidal activity of *R. communis* is likely attributable to secondary metabolites — namely condensed tannins, phenolic compounds, and flavonoids — present in the plant. These results are consistent with those of Adamou *et al.* (2021), who demonstrated ovicidal activity of aqueous (IC50: 3.65 ± 0.16) and methanolic (IC50: 3.44 ± 0.13) extracts of *Portulaca oleracea* after 48 h incubation of *H. contortus* eggs. Studies by Yongwa *et al.* (2020) on aqueous and ethanolic extracts of *Senna italica* reached the same conclusion.



HMEFRc: Hydromethanolic extract of *Ricinus communis* leaves; ***: highly significant difference

Figure 2: Variation in egg hatching inhibition rate (a) and LC_{50} of *Ricinus communis* and levamisole on *Haemonchus contortus* eggs (b).

3.3.2. Larvicidal Activity of *Ricinus communis*

The paralysis rates of stage 3 larvae of *Haemonchus contortus* due to the hydromethanolic extract of *R. communis* and levamisole are represented by the curves in Figure 3. These rates varied with concentrations and incubation time. LC_{50} values, conversely, were inversely proportional to incubation time, ranging between 0.22 mg/mL ± 0.19 and 0.38 mg/mL ± 0.04, respectively (Figure 4). The anthelmintic activity of the hydromethanolic extract showed no significant difference (P> 0.05) compared to levamisole. At 48 h incubation, the maximum effect (100%) was equally high for both the hydromethanolic extract of *Ricinus communis* and levamisole. All concentrations induced total larval paralysis with levamisole, while with the extract, only concentrations of 1.5, 2, 2.5, and 3 mg/mL induced complete paralysis. The minimum concentration (1 mg/mL) at 48 hours showed 80% larvicidal paralysis with *Ricinus communis* compared to 100% with levamisole. This may be explained by the fact that levamisole is a synthetic chemical compared to the crude plant extract. Total paralysis was observed after 72 hours incubation with both products at all concentrations, demonstrating anthelmintic activity on stage 3 larvae of *H. contortus*. No significant difference (P> 0.05) was observed between the extract and levamisole at 48 and 72 hours, indicating that at 72 hours both products have equivalent effects, and that the extract requires slightly more time to achieve maximum effect at low concentration (0.5 mg/mL). These results are in agreement with those of Haman *et al.* (2021), who demonstrated larvicidal activity of aqueous and hydroethanolic extracts of *Tephrosia pedicellata* after 48 h incubation on stage 3 larvae of *H. contortus*. Similarly, Brunet *et al.* (2007) showed that sainfoin extract, a tannin-rich plant, acts on the exsheathment kinetics of *H. contortus* L3 larvae and that this inhibitory effect depends on extract concentration. Death of stage 3 larvae was confirmed by a change in coloration observed after 48 h incubation for 30 minutes: purple for live larvae and yellow for dead larvae.

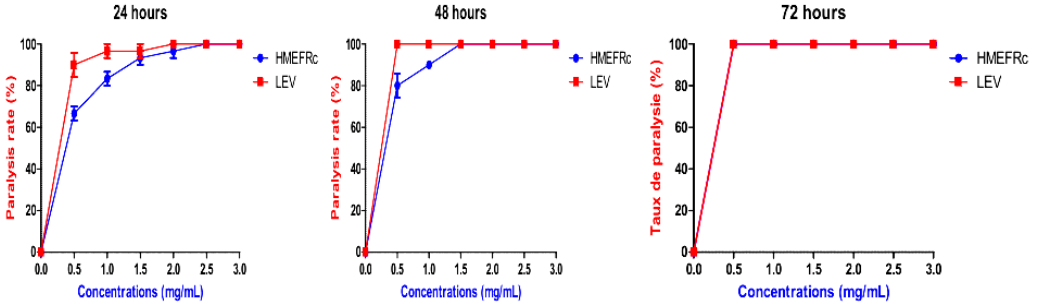
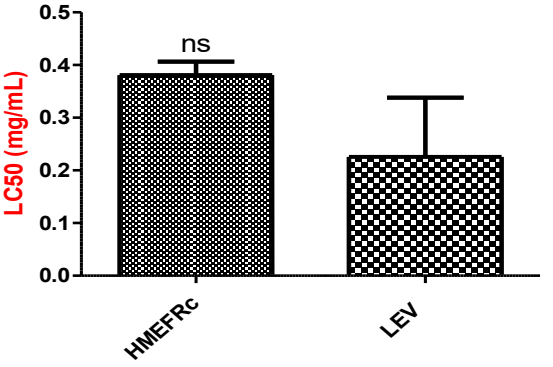


Figure 3: Vermifuge effects of the hydromethanolic extract of *Ricinus communis* and levamisole on *Haemonchus contortus* stage 3 larvae after 24, 48, and 72 hours incubation

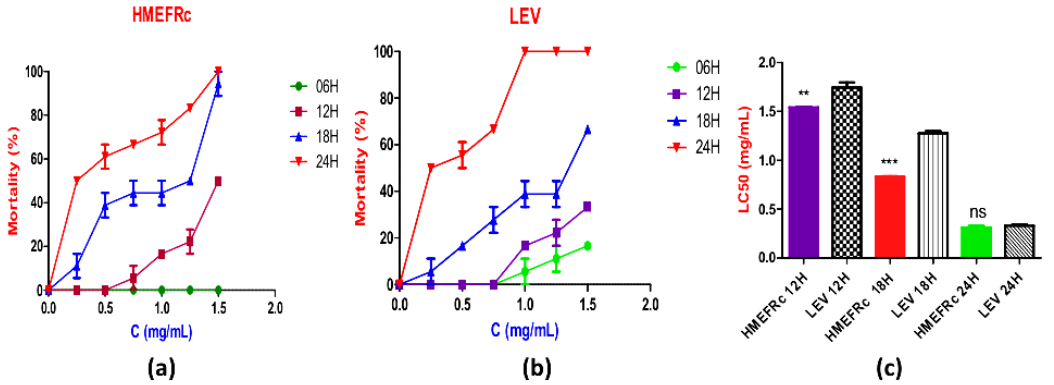


HMEFRc: Hydromethanolic extract of *Ricinus communis* leaves; LEV: Levamisole; ns: not significant

Figure 4: Comparative effect of the hydromethanolic extract of *Ricinus communis* and levamisole on *Haemonchus contortus* stage 3 larvae

3.3.3. Anthelmintic Effect of *Ricinus communis* on Adult Female *Haemonchus contortus* Worms

Worm mortality rates varied with concentrations and incubation time (Figure 5). LC_{50} values were inversely proportional to incubation time. Figure 5a shows that after 6 h incubation, no mortality was observed. Mortality rates progressively increased after 12 and 18 hours incubation, ranging from 16.66% to 50% and from 83.33% to 100%, respectively, at different concentrations. However, after 24 h incubation, a 100% mortality rate was observed across all concentrations. The hydromethanolic extract of *Ricinus communis* demonstrated significant *in vitro* anthelmintic activity against adult female *Haemonchus contortus* parasites. Lethal concentrations (LC_{50}) were variable, ranging from 1.54 mg/mL ± 0.005 at 12 hours (very significant difference, $P< 0.01$) to 0.83 mg/mL ± 0.006 at 18 hours (highly significant difference, $P< 0.001$), and 0.31 mg/mL ± 0.02 at 24 h (non-significant difference, $P> 0.05$) compared to levamisole (Figure 5b). Mortality rates ranged from 0% to 16.66% at 6 hours; from 16.66% to 33.33% at 12 hours with LC_{50} 1.74 mg/mL ± 0.09; from 33.33% to 66.66% at 18 hours for LC_{50} 1.27 mg/mL ± 0.03; and 100% at various concentrations at 24 hours with LC_{50} 0.33 mg/mL ± 0.02.



HMEFRc: Hydromethanolic extract of *Ricinus communis* leaves; LEV: Levamisole; ns: not significant; **: very significant difference; ***: highly significant difference

Figure 5: Anthelmintic effects of hydromethanolic extracts of *Ricinus communis* (a) and levamisole (b) on adult female *Haemonchus contortus*, and comparative effects (c).

The negative control (PBS) had no visible effect on worms throughout all incubation periods, whereas the hydromethanolic extract considerably reduced parasite survival. These results are consistent with those of Dedehou *et al.* (2014) on the same parasite using the crude ethanolic extract of *Artemesia campestris*, conducted under the same conditions but at different concentrations, yielding 100% mortality after 24 hours. Haman *et al.* (2024) also demonstrated anthelmintic activity of aqueous and hydroethanolic extracts of *Tephrosia pedicellata* at the same incubation times on adult female *Haemonchus contortus*, finding 100% mortality after 24 hours. It may thus be said that *Ricinus communis* possesses the ability to act on *Haemonchus contortus* eggs, as certain secondary metabolites found in the hydromethanolic extract penetrate the egg shell and larval cuticle through osmosis via the circulatory system, arresting blastomere development and thereby causing death by starvation or paralysis (Athanasiadou *et al.*, 2001).

3.4. Acute Toxicity

Evaluation of the acute toxicity of the hydromethanolic extract of *Ricinus communis* leaves (Table 2), administered orally at 2000 mg/kg body weight to *Mus musculus* mice, revealed no mortality or severe clinical manifestations during the first 4 hours post-administration, nor during the 14-day observation period. The absence of mortality suggests that the oral LD_{50} of the hydromethanolic extract of *R. communis* leaves exceeds 2000 mg/kg, classifying this extract as slightly toxic according to OECD acute toxicity test guidelines. However, the observed weight loss may be a consequence of reduced food intake due to appetite loss. In prior work, Guergour (2011) studied the acute toxicity of *Ricinus communis* oil in female mice at different doses (2190, 3650, 7300, 10950, and 14600 mg/kg), observing clinical signs including convulsions, agitation, cardiac acceleration, piloerection, appetite loss, and death from the 3650 mg/kg dose onwards. These results differ from the present study, and the differences may be attributed to the higher minimum toxic dose used by Guergour (2011) (3650 mg/kg), as well as to differences in the plant part used, the solvent, and environmental conditions.

Indeed, several authors have shown that the severe acute toxicity of *R. communis* is primarily associated with seeds rich in ricin, responsible for gastrointestinal, neurological, and sometimes fatal effects in laboratory animals and ruminants. Conversely, leaves mainly contain secondary metabolites such as flavonoids, alkaloids, and phenolic compounds, whose biological effects are generally less acutely toxic and sometimes associated with beneficial pharmacological properties (Abomughaid *et al.*, 2024).

Table 2: Effects of the hydromethanolic extract of *Ricinus communis* leaves on selected physiological parameters in white *Mus musculus* Swiss strain mice during the first 4 h and the 14 days following administration

Parameter	H1	H2	H3	H4	D2	D3	D4	D5	D6	D7	D8	D9	D10	D11	D12	D13	D14
Grooming	Y	Y	Y	Y	N	N	N	N	N	N	N	N	N	N	N	N	N
Salivation	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Coat	Nor	Nor	Nor	Nor	Nor	Nor	Nor	Nor	Nor	Nor	Nor	Nor	Nor	Nor	Nor	Nor	Nor
Noise reaction	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Stool appearance	Nor	Nor	Nor	Nor	Nor	Nor	Nor	Nor	Nor	Nor	Nor	Nor	Nor	Nor	Nor	Nor	Nor
Motility	Nor	Nor	Nor	Nor	Nor	Nor	Nor	Nor	Nor	Nor	Nor	Nor	Nor	Nor	Nor	Nor	Nor
Convulsions	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Sleep	Y	Y	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Deaths	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Nor = normal; N = no; Y = yes; Dose: 2000 mg/kg body weight; H = hour; D = day

CONCLUSION

The results obtained in this study show that the hydromethanolic extract of *Ricinus communis* leaves is rich in secondary metabolites such as phenolic compounds, tannins, and flavonoids, which are responsible for its demonstrated anthelmintic activity. The leaves of *Ricinus communis* exhibit remarkable *in vitro* vermicidal effects against all developmental stages of *Haemonchus contortus* (eggs, stage 3 larvae, and adult worms). The acute toxicity test performed on female mice at a single dose of 2000 mg/kg showed no toxic effects in these animals.

Conflict of interest:
The authors declare no conflict of interest.

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