Acta Scientific Veterinary Sciences (ISSN: 2582-3183)

Volume 6 Issue 11 November 2024

Research Article

# Evaluation of Acaricidal Efficacy of *Curcuma Longa*, Curcumin and Nanocurcumin Against *Rhipicephalus (b.) Microplus*

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**DOI:** 10.31080/ASVS.2024.06.0941

**Received:** October 15, 2024

**Published:** October 30, 2024



## Abstract

The study was conducted to evaluate acaricidal efficacy of *Curcuma longa*, curcumin and nanocurcumin against *Rhipicephalus (B.) microplus.* The *in vitro* evaluation of acaricidal efficacy of *Curcuma longa,* curcumin and nanocurcumin was done by adult immersion test and larval packet test. Ethanolic extract of *Curcuma longa* was used in three concentrations viz. 10, 15 and 20 per cent and curcumin and nanocurcumin at 10, 15 and 20 ppm against *Rhipicephalus (B.) microplus* and results were compared with standard chemical acaricide, deltamethrin.

**Keywords:** Curcumin; *Curcuma Longa*; Nanocurcumin; *Rhipicephalus (B.) Microplus;* Deltamethrin

## Introduction

Parasitic infestation severely affects the health of animal and also causes severe economic losses. Rhipicephalus (B.) microplus (previously Boophilus microplus) is most important tick parasite of livestock worldwide. Tick infestation cause economic losses due to damage to hide, lower productivity, immune system depression and the transmission of infections such as Babesia bigemina, Babesia bovis and Anaplasma marginale [1]. Although lots of acaricidal drugs are available in the market but these drugs are causing alarming tick resistance worldwide. Hence, to overcome tick resistance, phytoacaricides are used to control ticks.

Curcuma longa commonly known as Turmeric/Indian saffron/the golden spice, is perineal herb belongs to the family Zingiberaceae. Curcuma longa L. has been widely used in ayurvedic medicine as natural antiseptic, disinfectant, anti-inflammatory, analgesic, to aid digestion and to treat skin irritations. Principal curcuminoid of Curcuma longa is curcumin also known as diferuloylmethane is a yellow colored pigment and insoluble in water. Curcumin has various types of biological and pharmacological activities such as anti-bacterial, anti-inflammatory, anti-oxidant, anti-arthritic, anti-diabetic, wound healing and anti-cancer properties [2].

The development of nanotechnology brought revolution in pharmaceutical industry. Nanomaterials are defined as those materials that have surface structure or external dimensions at the nanoscale i.e. in the range of 1–100 nm [3]. Nanoparticles possess several unique properties due to their specific size, shape,

composition, greater surface area to volume ratio and purity of individual constituents. Due to these characteristics, they can be employed as drug delivery agents, catalysts, pollutant remediation agents, water disinfectants and quantum dots for electronics [4,5]. Herbal nanotechnology is the most promising new drug delivery system results in nano-formulations with many advantages over conventional phytoconstituent formulations, including enhanced permeability, dissolution, bioavailability, pharmacological activity, stabilization, enhanced biodistribution etc [6].

## Materials and Methods

The present research work was carried out in the Department of Veterinary Pharmacology and Toxicology, College of Veterinary Science and Animal Husbandry, N.D.V.S.U., Jabalpur, Madhya Pradesh.

### Experimental material

Fresh rhizomes of Curcuma longa rhizomes were procured from Department of Plant Physiology, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur (M.P.).

### Chemicals

Curcumin (Sigma Aldrich, USA) and Nanocurcumin (Herbzenica Lifescience Pvt. Ltd.) were used in experiment.

### Preparation of ethanolic extract of *Curcuma longa*

20 g powder of Curcuma longa was taken in thimble made up of Whatman filter paper no. 1. Thimble was then placed in soxhlet apparatus with 500 ml round bottom flask containing 400 ml solvent at a temperature of 80 ± 5ºC. The extraction was allowed to continue for 12 hrs. The extract was collected in petri plates and kept on water bath for evaporating the extra solvent. The extract was kept in airtight container at 4ºC for further study [7].

### Evaluation of acaricidal efficacy of *Curcuma longa*, curcumin and nanocurcumin

### Collection, identification and rearing of ticks

The ticks were collected in early morning from cattle of dairy farms (including livestock farm, Adhartal) in and around Jabalpur. Fully engorged ticks from the ear, brisket, lower abdomen, between the thighs, perineal area, base of the tail, around the anus and the engorged fallen ticks from animal were randomly collected and placed into small container with a few small holes allowing air to circulate.

Collected ticks were identified as per the method [8]. Rhipicephalus (B.) microplus ticks were sorted out from the identified tick populations for determining acaricidal activity of different compounds.

Ticks for Larval Packet Test (LPT) were placed in glass vials covered with muslin cloth and rubber band. They were placed in a desiccator and kept for incubation in B.O.D. incubator at a temperature of 28±1°C and 85±5 per cent relative humidity maintained by potassium chloride solution for oviposition (Plate 02). After complete oviposition, the vials containing eggs were capped with the cotton plug. The hatched larvae were preserved in B.O.D. incubator until used in tests.

### Adult Immersion test

Adult immersion test was conducted according to [9] with slight modification. The engorged female ticks, collected from field were washed thoroughly in distilled water and dried using filter paper. The ticks were randomly divided in 33 groups (5 ticks in each group). Distilled water served as control while 30 ppm concentration of deltamethrin served as positive control. Different concentrations of Curcuma longa (10 per cent, 15 per cent and 20 per cent), curcumin (10 ppm, 15 ppm and 20 ppm) and nanocurcumin (10 ppm, 15 ppm and 20 ppm) were prepared. Individual tick was weighed and immersed in the test compound for 5 min. Ticks were recovered and dried on tissue paper. For each concentration, three replications were maintained (Table 01). The treated ticks were kept at room temperature for 24 hours then transferred to desiccator and kept in B.O.D. incubator at a temperature of 28±1°C and relative humidity 85±5 per cent for oviposition. These ticks were observed daily for oviposition and death up to 14 days. The per cent adult tick mortality and the weight of the egg mass laid by treated ticks were observed in comparison to control group.

In this test, the following parameters were calculated

- **Mortality:** recorded up to 14 days post treatment
- The weight of egg masses laid by the live ticks
- $$\text{Reproductive index} = \frac{\text{Weight of egg laid (mg)}}{\text{Weight of adult females (mg)}}$$

$$\text{Inhibition of oviposition (IO per cent)} = \frac{\text{RI (control group)} - \text{RI (treated group)}}{\text{RI (control group)}} \times 100$$

[10].

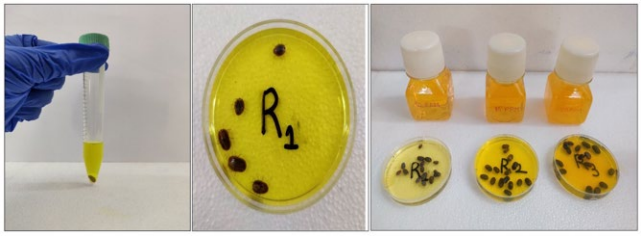

**Figure 1:** Adult immersion test for *Rhipicephalus (B.)* microplus tick.

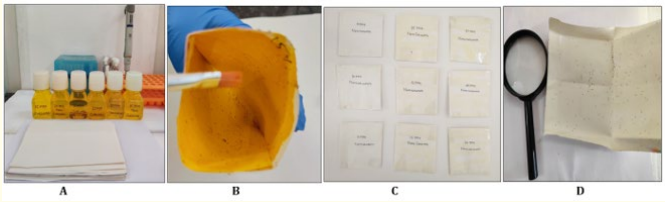

**Figure 2:** Larval packet test for *Rhipicephalus (B.)* microplus larvae

A. Materials required for larval packet test

B. Transfer of larvae in packets

C. Larval packet impregnated with different test agent

D. Counting of live and dead larvae after an exposure of 24 hours.

## Larval packet test

The larval packet test was performed as per [11] with slight modification to determine the in vitro acaricidal efficacy of the test compounds against larvae of Rhipicephalus (B.) microplus. Engorged female ticks were obtained from the cattle in the study area, identified, cleaned, stored in a petri dish and maintained at 28 ± 1°C and 85 ± 5 per cent relative humidity. The female ticks were examined daily until oviposition. The eggs were separated and allowed to hatch in glass vials with a cotton plug and kept in optimal conditions (Plate 04). The obtained seed ticks were maintained at 28 ± 1°C and 85 ± 5 per cent relative humidity for 14-21 days. The larvae aged between 14 to 21 days were subjected to a larval packet test. Packets made of Whatman filter paper No. 1 (12 cm x 18 cm) were impregnated with 3 ml of respective compounds and dried at room temperature for two hours. About 100 larvae were placed in an impregnated filter paper packet and the top of the packet was sealed with white tape. For each concentration, three replications were maintained (Table 01). The closed packets were incubated at 28 ± 1°C and 85 ± 5 per cent relative humidity for 24 hours. After 24 hours, observations for mortality were made by counting the dead and live larvae. All non-motile tick larvae were counted as dead. The data obtained were expressed as per cent mortality at each concentration.

The per cent mortality in all of the experimental batches' larvae was corrected by applying Abbott's formula [12].

$$\text{Per cent mortality} = \frac{\text{Number of dead larvae}}{\text{Total number of larvae}} \times 100$$

$$\text{Corrected per cent mortality} = \frac{\text{Per cent Test Mortality-per cent Control Mortality}}{\text{100-per cent Control Mortality}}$$

| Treatment | Concentration | No. of replicate | No. of adult ticks per replicate | No. of larvae per replicate |
|---|---|---|---|---|
| Negative control | NA | 3 | 5 | 100 |
| Ethanolic extract of *Curcuma longa* | 10 per cent | 3 | 5 | 100 |
| | 15 per cent | 3 | 5 | 100 |
| | 20 per cent | 3 | 5 | 100 |
| Curcumin | 10 ppm | 3 | 5 | 100 |
| | 15 ppm | 3 | 5 | 100 |
| | 20 ppm | 3 | 5 | 100 |
| Nanocurcumin | 10 ppm | 3 | 5 | 100 |
| | 15 ppm | 3 | 5 | 100 |
| | 20 ppm | 3 | 5 | 100 |
| Deltamethrin (Positive control) | 30 ppm | 3 | 5 | 100 |

**Table 1:** Experimental design.

## Statistical analysis

Statistical analysis was done using one way analysis of variance (ANOVA) as per the procedure described by [13].

## Results and Discussion

### Efficacy of ethanolic extract of Curcuma longa in adult immersion test

The acaricidal efficacy of ethanolic extract of Curcuma longa was evaluated in three concentrations viz. 10 per cent, 15 per cent and 20 per cent against adult female Rhipicephalus (B.) microplus. The per cent mortality of adult female recorded was 60.00 per cent, 73.33 per cent and 100 per cent by 10 per cent, 15 per cent and 20 per cent concentration of ethanolic extract of Curcuma longa, respectively. The weight of egg mass laid by adult female was 56.40 ± 1.30 mg in control, however it was significantly reduced to 36.97 ± 1.04 mg and 23.11 ± 0.79 mg in group treated with 10 per cent and 15 per cent ethanolic extract of Curcuma longa, respectively. Accordingly, the reproductive index was also reduced by ethanolic extract of Curcuma longa. The reproductive index was 0.53 ± 0.013 in control and it was significantly reduced to 0.37 ± 0.009 and 0.23 ± 0.007 by 10 per cent and 15 percent ethanolic extract of Curcuma longa. Inhibition of oviposition was significantly increased with increase in concentration of ethanolic extract of Curcuma longa. Inhibition of oviposition was 100 per cent by 20 per cent of ethanolic extract of Curcuma longa. However, it was 28.28 ± 1.98 and 56.47 ± 1.44 by 10 per cent and 15 per cent concentration of ethanolic extract of Curcuma longa (Table 2 and Figure 3).

Results of present study indicates that there was significant increase in per cent mortality and inhibition of oviposition with increase in concentration of Curcuma longa. These finding are in agreement with [14,15]. and [16] Abdel-Shafy [14] reported acaricidal efficacy of ethanolic extract of Curcuma longa on second nymph of Ornithodoras savignyi. Bressanin [15] evaluated in vitro acaricidal efficacy of essential oil of Curcuma zeodaria and Alpinia zerumbat rhizomes against adult and larvae of Rhipicephalus (B.) microplus. Souza Chagas [16] evaluated efficacy of 11 essential oils on adult and larvae of Rhipicephalus (B.) microplus. Curcuma longa showed highest acaricidal efficacy on adult and larvae of Rhipicephalus (B.) microplus.

| Concentration of extract (per cent) | Live tick weight (mg) | Mortality (per cent) | Weight of egg mass laid (mg) | Reproductive index | Inhibition of oviposition (per cent) |
|---|---|---|---|---|---|
| Control | 105.10 ± 1.86 | 00.00 | $56.40^{a}$ ± 1.30 | $0.53^{a}$ ± 0.013 | 00.00 ± 0.00 |
| 10 | 97.41 ± 1.47 | 60.00 | $36.97^{b}$ ± 1.04 | $0.37^{b}$ ± 0.009 | $28.28^{c}$ ± 1.98 |
| 15 | 100.69 ± 2.08 | 73.33 | $23.11^{c}$ ± 0.79 | $0.23^{c}$ ± 0.007 | $56.47^{b}$ ± 1.44 |
| 20 | 107.33 ± 2.17 | 100.00 | 00.00 ± 0.00 | 00.00 ± 0.00 | $100.00^{a}$ ± 0.00 |
| Deltamethrin | 106.68 ± 2.33 | 100.00 | 00.00 ± 0.00 | 00.00 ± 0.00 | $100.00^{a}$ ± 0.00 |

**Table 2:** Efficacy of ethanolic extract of *Curcuma longa* against *Rhipicephalus (B.) microplus* in adult immersion test.

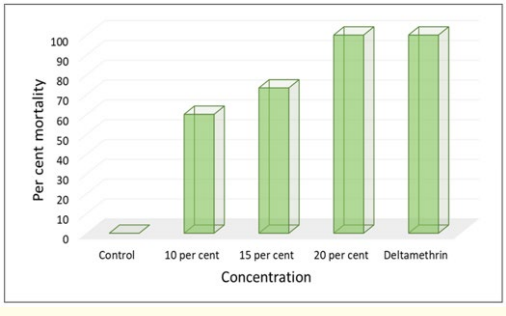


**Figure 3:** Efficacy of ethanolic extract of Curcuma longa on mortality of *Rhipicephalus (B.)* microplus in adult immersion test.

### Efficacy of curcumin in adult immersion test

The acaricidal efficacy of curcumin was evaluated in three concentrations viz. 10 ppm, 15 ppm and 20 ppm against adult female Rhipicephalus (B.) microplus. The per cent mortality of adult female recorded was 00.00 per cent, 26.66 per cent and 40.00 per cent by 10 ppm, 15 ppm and 20 ppm concentration of curcumin, respectively. The weight of egg mass laid by adult female was 56.40 ± 1.30 mg in control, however it was significantly reduced to 46.76 ± 0.96 mg, 41.62 ± 2.02 mg and 39.43 ± 0.86 mg in group treated with 10, 15 ppm and 20 ppm concentration of curcumin, respectively. Accordingly, the reproductive index was also reduced by curcumin. The reproductive index was 0.53 ± 0.013 in control

and it was significantly reduced to 0.47 ± 0.001, 0.42 ± 0.008 and 0.37 ± 0.009 by 10 ppm, 15 ppm and 20 ppm concentration of curcumin, respectively. Inhibition of oviposition was significantly increased with increase in concentration of curcumin. Inhibition of oviposition was 10.93 ± 7.44, 20.12 ± 1.62 and 29.80 ± 1.72 by 10 ppm, 15 ppm and 20 ppm concentration of curcumin, respectively (Table 03 and Figure 04).

Results of present study indicates that there was significant increase in per cent mortality and inhibition of oviposition with increase in concentration of curcumin. Reproductive index was significantly reduced as compared to control with increase in concentration of curcumin. Results are in agreement with findings of [17]. who evaluated acaricidal efficacy of curcumin on adult Rhipicephalus (B.) microplus at different concentration.

| Concentration of curcumin | Live tick weight (mg) | Mortality (per cent) | Weight of egg mass laid by (mg) | Reproductive index | Inhibition of oviposition (per cent) |
|---|---|---|---|---|---|
| Control | 105.10 ± 1.86 | 00.00 | $56.40^{a}$ ± 1.30 | $0.53^{a}$ ± 0.013 | 00.00 ± 0.00 |
| 10 ppm | 99.06 ± 3.28 | 00.00 | $46.76^{b}$ ± 0.96 | $0.47^{b}$ ± 0.001 | $10.93^{d}$ ± 7.44 |
| 15 ppm | 97.83 ± 3.41 | 26.66 | $41.62^{c}$ ± 2.02 | $0.42^{c}$ ± 0.008 | $20.12^{c}$ ± 1.62 |
| 20 ppm | 105.73 ± 1.41 | 40.00 | $39.43^{d}$ ± 0.86 | $0.37^{d}$ ± 0.009 | $29.80^{b}$ ± 1.72 |
| Deltamethrin | 106.68 ± 2.33 | 100.00 | 00.00 ± 0.00 | 00.00 ± 0.00 | $100.00^{a}$ ± 0.00 |

**Table 03:** Efficacy of curcumin against *Rhipicephalus (B.) microplus* in adult immersion test.

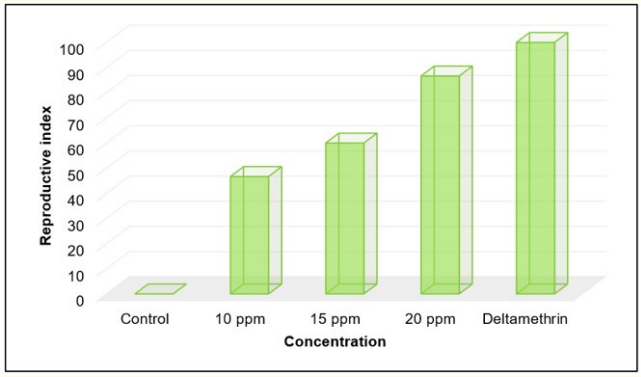


**Figure 4:** Efficacy of curcumin on mortality of *Rhipicephalus (B.)* microplus in adult immersion test.

## Efficacy of nanocurcumin in adult immersion test

Nanocurcumin was used in three concentrations viz. 10 ppm, 15 ppm and 20 ppm for evaluating its acaricidal efficacy against adult female Rhipicephalus (B.) microplus. The per cent mortality of adult female recorded was 46.67 per cent, 60.00 per cent and 86.66 per cent by 10 ppm concentration of nanocurcumin, 15 ppm concentration of nanocurcumin and 20 ppm concentration of nanocurcumin, respectively. The weight of egg mass laid by adult female was 56.40 ± 1.30 mg in control, however it was significantly reduced to 44.03 ± 2.16 mg, 35.78 ± 0.80 mg and 25.66 ± 1.52 mg in group treated with 10 ppm concentration of nanocurcumin, 15 ppm concentration of nanocurcumin and 20 ppm concentration of nanocurcumin, respectively**.** Accordingly, the reproductive index was also reduced by nanocurcumin. The reproductive index was 0.53 ± 0.013 in control and it was significantly reduced to 0.44 ± 0.008, 0.27 ± 0.007 and 0.24 ± 0.009 by 10 ppm concentration of nanocurcumin, 15 ppm concentration of nanocurcumin and 20 ppm concentration of nanocurcumin, respectively. Inhibition of oviposition was significantly increased with increase in concentration of nanocurcumin. Inhibition of oviposition was 16.97 ± 1.66, 32.07 ± 1.34 and 54.71 ± 1.76 by 10 ppm concentration of nanocurcumin, 15 ppm concentration of nanocurcumin and 20 ppm concentration nanocurcumin, respectively (Table 04 and Figure 05).

Results of present study indicates that there was significant increase in per cent mortality and inhibition of oviposition with increase in concentration of nanocurcumin. Reproductive index was significantly reduced as compared to control with increase in concentration of nanocurcumin. Results are in agreement with findings of [17] who evaluated acaricidal efficacy of synthesized nanocurcumin nanoparticles on adult Rhipicephalus (B.) microplus at different concentration.

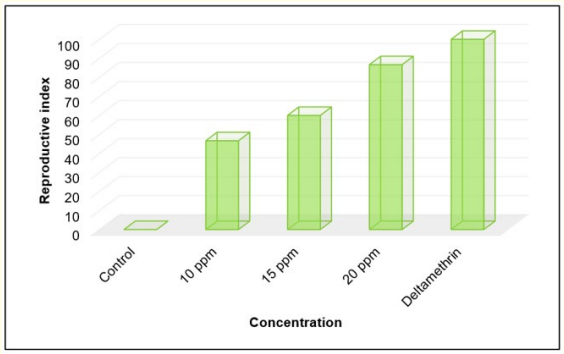


**Figure 5:** Efficacy of nanocurcumin on mortality of *Rhipicephalus (B.)* microplus in adult immersion test.

| Concentration of nanocurcumin | Live tick weight (mg) | Mortality (per cent) | Weight of egg mass laid (mg) | Reproductive index | Inhibition of oviposition (per cent) |
|---|---|---|---|---|---|
| Control | 105.10 ± 1.86 | 00.00 | $56.40^{a}$ ± 1.30 | $0.53^{a}$ ± 0.013 | 00.00 ± 0.00 |
| 10 ppm | 100.01 ± 4.33 | 46.67 | $44.03^{b}$ ± 2.16 | $0.44^{b}$ ± 0.008 | $16.97^{d}$ ± 1.66 |
| 15 ppm | 99.53 ± 1.72 | 60.00 | $35.78^{c}$ ± 0.80 | $0.27^{c}$ ± 0.007 | $32.07^{c}$ ± 1.34 |
| 20 ppm | 105.87 ± 3.05 | 86.66 | $25.66^{d}$ ± 1.52 | $0.24^{c}$ ± 0.009 | $54.71^{b}$ ± 1.76 |
| Deltamethrin | 106.68 ± 2.33 | 100.00 | 00.00 ± 0.00 | 00.00 ± 0.00 | $100.00^{a}$ ± 0.00 |

**Table 4:** Efficacy of nanocurcumin against *Rhipicephalus (B.) microplus* in adult immersion test.

## Efficacy of ethanolic extract of *Curcuma longa*, curcumin and nanocurcumin against *Rhipicephalus (B.)* microplus larvae in larval packet test

### Efficacy of ethanolic extract of *Curcuma longa* in larval packet test

The effect of different concentrations of ethanolic extract of Curcuma longa on mortality of Rhipicephalus (B.) microplus larvae has been presented in Table 05 and Figure 04. Ethanolic extract of Curcuma longa in concentration of 10 per cent, 15 per cent and 20 per cent were tested to evaluate their acaricidal efficacy against Rhipicephalus (B.) microplus larvae. The efficacy of 10 per cent and 20 per cent of ethanolic extract of Curcuma longa was comparable to standard chemical acaricide deltamethrin. Larval mortality was 94.33 per cent, 99.66 per cent and 98.66 per cent by 15 per cent ethanolic extract of Curcuma longa, 20 per cent ethanolic extract of Curcuma longa and deltamethrin, respectively. The larval mortality was significantly reduced to 55.33 per cent by 10 per cent ethanolic extract of Curcuma longa.

Results of present study indicates that there was significant increase in larval mortality with increase in concentration of Curcuma longa. Results are in agreement with [18] who evaluated larvicidal effect of Curcuma longa which was in dose dependent manner. The larval mortality was found 100 per cent at 10 per cent concentration of Curcuma longa.

### Efficacy of curcumin in larval packet test

The effect of different concentrations of curcumin on mortality of Rhipicephalus (B.) microplus larvae has been presented in Table 06 and Figure 05. Curcumin was tested in concentration of

| Concentration of extract (per cent) | No. of replication | No. of treated larvae in each replica | Live larvae | Dead larvae | Mortality (per cent) | Corrected mortality (per cent) |
|---|---|---|---|---|---|---|
| Control | 3 | 100 | 100.00 ± 0.00 | 00.00 ± 0.00 | 00.00 | 00.00 |
| 10 | 3 | 100 | 44.66 ± 4.91 | 55.33 ± 4.91 | 55.33[b] | 55.33[b] |
| 15 | 3 | 100 | 05.66 ± 2.33 | 94.33 ± 2.02 | 94.33[a] | 94.33[a] |
| 20 | 3 | 100 | 00.33 ± 0.33 | 99.66 ± 0.33 | 99.66[a] | 99.66[a] |
| Deltamethrin | 3 | 100 | 01.33 ± 0.33 | 98.66 ± 1.33 | 98.66[a] | 98.66[a] |

**Table 5:** Efficacy of ethanolic extract of *Curcuma longa* against *Rhipicephalus (B.) microplus* in larval packet test.

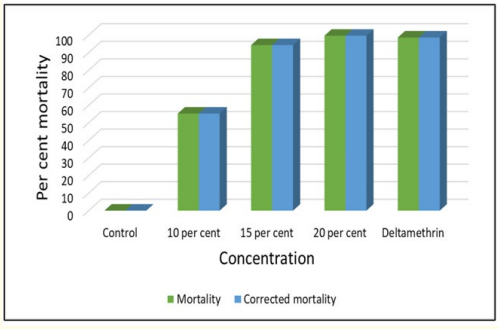


**Figure 6:** Efficacy of Curcuma longa against *Rhipicephalus (B.)* microplus in larval packet test Efficacy of curcumin against *Rhipicephalus (B.)* microplus in larval packet test.

10 ppm, 15 ppm and 20 ppm to evaluate their acaricidal efficacy against Rhipicephalus (B.) microplus larvae. The efficacy of 20 ppm concentration of curcumin was comparable to standard chemical acaricide deltamethrin. Larval mortality was 67.66 and 98.66 per cent by 20 ppm concentration of curcumin and deltamethrin, respectively. The larval mortality was significantly reduced to 54.66 and 44.66 per cent by 15 ppm concentration of curcumin and 10 ppm concentration of curcumin, respectively.

Results of present study indicates that there was significant increase in larval mortality with increase in concentration of curcumin. Results are in agreement with findings of [17] who evaluated acaricidal efficacy of curcumin on larvae of Rhipicephalus (B.) microplus at different concentrations.

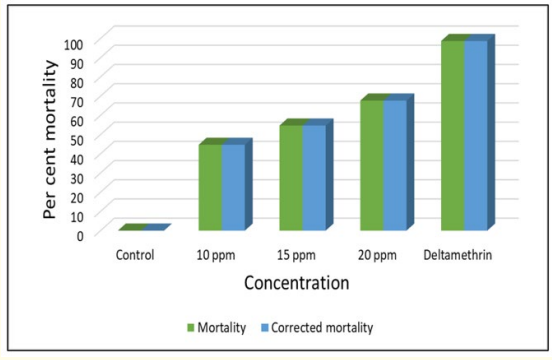


**Figure 7:** Efficacy of curcumin against *Rhipicephalus (B.)* microplus in larval packet test.

| Concentration of Curcumin | No. of replication | No. of treated larvae in each replica | Live larvae | Dead larvae | Mortality (per cent) | Corrected mortality (per cent) |
|---|---|---|---|---|---|---|
| Control | 3 | 100 | 100.00 ± 0.00 | 00.00 ± 0.00 | 00.00 | 00.00 |
| 10 ppm | 3 | 100 | 65.33 ± 6.69 | 44.66 ± 7.09 | 44.66[d] | 44.00[d] |
| 15 ppm | 3 | 100 | 45.33 ± 4.81 | 54.66 ± 4.91 | 54.66[c] | 54.66[c] |
| 20 ppm | 3 | 100 | 33.66 ± 2.84 | 67.66 ± 3.75 | 67.66[b] | 67.66[b] |
| Deltamethrin | 3 | 100 | 01.33 ± 0.33 | 98.66 ± 1.33 | 98.66[a] | 98.66[a] |

**Table 6:** Efficacy of curcumin against *Rhipicephalus (B.) microplus* in larval packet test.

### Efficacy of nanocurcumin against *Rhipicephalus (B.)* microplus in larval packet test

The effect of different concentrations of nanocurcumin on mortality of Rhipicephalus (B.) microplus larvae has been presented in Table 07 and Figure 06. Nanocurcumin was tested in concentration of 10 ppm, 15 ppm and 20 ppm to evaluate their acaricidal efficacy on Rhipicephalus (B.) microplus larvae. The efficacy of 10 ppm and 20 ppm of concentrations of nanocurcumin was comparable to standard chemical acaricide deltamethrin. Larval mortality was 81.66 per cent, 93.33 per cent and 98.66 per cent by 15 ppm concentration of nanocurcumin, 20 ppm concentration of nanocurcumin and deltamethrin, respectively. The larval mortality was significantly reduced to 69.66 per cent by 10 ppm concentrations of nanocurcumin.

The results of present study indicates that there was significant increase in larval mortality with increase in concentration of nanocurcumin. Results are in agreement with findings of [17] who evaluated acaricidal efficacy of synthesized curcumin nanoparticles on larvae of Rhipicephalus (B.) microplus at different concentration.

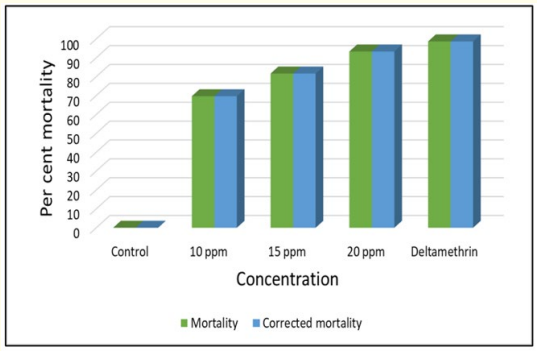


**Figure 8:** Efficacy of nanocurcumin on mortality of *Rhipicephalus (B.)* microplus in larval packet test.

| Concentration of nanocurcumin | No. of replication | No. of treated larvae in each replica | Live larvae | Dead larvae | Mortality (per cent) | Corrected mortality (per cent) |
|---|---|---|---|---|---|---|
| Control | 3 | 100 | 100.00 ± 0.00 | 00.00 ± 0.00 | 00.00 | 00.00 |
| 10 ppm | 3 | 100 | 33.66 ± 2.04 | 69.99 ± 3.75 | 69.66[b] | 69.66[b] |
| 15 ppm | 3 | 100 | 18.33 ± 2.30 | 81.66 ± 1.33 | 81.66[a] | 81.66[a] |
| 20 ppm | 3 | 100 | 06.66 ± 1.20 | 93.33 ± 1.20 | 93.33[a] | 93.33[a] |
| Deltamethrin | 3 | 100 | 01.33 ± 0.33 | 98.66 ± 1.33 | 98.66[a] | 98.66[a] |

**Table 7:** Efficacy of nanocurcumin against *Rhipicephalus (B.) microplus* in larval packet test.

## Conclusion

Our result showed 20 per cent concentration of ethanolic extract of Curcuma longa was found to be most effective against adult Rhipicephalus (B.) microplus followed by 15 per cent concentration of ethanolic extract of Curcuma longa followed by 20 ppm concentration of nanocurcumin. 20 per cent concentration of ethanolic extract of Curcuma longa was most effective against larvae of Rhipicephalus (B.) microplus followed by 20 ppm concentration of nanocurcumin.

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