Evaluation of Selected Flavonoids for the Anthelmintic and Skeletal Muscle Relaxant Activity using Animal Models

Bala Yaswanth Kumar S*, Bantupalli Suranjana, Atluri Deekshit

VI Year Pharm.D, Kommareddy Venkata Sadasiva Rao Siddhartha College of Pharmaceutical Sciences, Vijayawada-520010, Andhra Pradesh, India

Abstract

Most fruits and vegetables contain flavonoids, a type of phytoneutrient. As well as carotenoids, they’re responsible for fruits and vegetable brilliant hues. Some other phytonutrients such as flavonoids are strong antioxidants with anti-inflammatory and immune properties. There are many flavonoids, including anthocyanins, flavones, flavonols, flavonoids, and isoflavonoids. Quercetin and chrysin were chosen for the investigation. Humans and other animals can contract Helminthiasis (helminthiases), sometimes known as worm infection. Tapeworms, roundworms, and flukes are only a few of the parasites that exist. Skeletal muscle relaxants are used to treat spasticity caused by upper motor neuron syndromes and muscle discomfort or musculoskeletal spasms created by peripheral disturbances. Samples of quercetin and chrysin were generated in the presence of 0.5% SCMC suspension at concentrations of 10, 20, 30, and 40 mg/mL and then analyzed. To keep track of photocell beam disruptions, a six-digit counter was utilized (locomotor activity). It was time to turn on the actophotometer and examine the locomotor behavior of each rat for five minutes. The basal activity levels of all the animals were recorded.

Keywords: Flavonoids, Anthelmintic, Skeletal Muscle relaxant, animal models

INTRODUCTION

Helminthiasis (plural helminthiases), also known as worm infection, is a macro parasitic disease of humans and other animals in which a part of the body becomes infected with parasitic worms known as helminths. There are many different types of parasites, which are broadly classified as tapeworms, flukes, and roundworms. They frequently live in their hosts' gastrointestinal tracts. However, they can burrow into other organs and cause physiological damage. Soil-transmitted helminthiasis and schistosomiasis are the most frequent helminthiases, both of which are considered neglected tropical illnesses. Soil-transmitted helminthiases may be responsible for parasitic infections in up to a quarter of the world’s population. One well-known example of the soil-transmitted helminth is Helminthiasis. Helminths can be transmitted to the final host in a variety of ways. Ingestion of contaminated vegetables, drinking water, and raw or undercooked meat is the most common route of infection. Contaminated food may contain the eggs of nematodes like Ascaris, Enterobius, and Trichuris, cestodes like Taenia, Hymenolepis, and Echinococcus, and trematodes like Fasciola. Taenia (pork, beef, and venison), Trichinella (pork and bear), Diphyllobothrium (fish), Clonorchis (fish), and Paragonimus (fish) are the most common pathogens found in raw or undercooked meats (crustaceans). Hookworms (Ancylostoma and Necator) and Strongylides are schistosomes and nematodes that can penetrate the skin directly. At last, Wuchereria, Onchocerca, and Dracunculus get transferred by mosquitoes and flies. Quercetin is a naturally occurring flavonoid that can be found in almost all edible vegetables and fruits. The Western diet contains a high amount of flavonoids, including anthocyanins, flavones, flavonols, flavonoids, and isoflavonoids. Quercetin and chrysin were chosen for the investigation.

MATERIALS AND METHODS

Drugs and chemicals

Sigma Chemical Co. supplied quercetin and chrysin (St. Louis, MO). Lifeline Formulations Pvt Limited, Vijayawada,
India, provided albendazole as a free sample. Lifeline Formulations Pvt. Ltd. in India provided free samples of albendazole and diazepam. Sodium carboxymethyl cellulose was supplied by Finsar Chemicals Ltd. of Ahmedabad, India (SCMC). Distilled water prepared from deionized water was used throughout the investigation. Analytical chemicals and reagents were employed.

Animals

In vitro, anthelmintic activity was assessed using adult earthworms (Pheretima Posthuma). Earthworms were collected and washed with normal saline at the Vermi Compost Unit in Vijayawada, Andhra Pradesh, India. In the study, earthworms measuring 6-8 cm in length were used. Sigma Chemical Co. supplied quercetin and chrysin (St. Louis, MO).

Evaluation of Anthelmintic activity

Because of its anatomical and physiological similarity to human intestinal roundworm parasites, the test was carried out in vitro on adult earthworms (Pheretima Posthuma) for preliminary evaluation of the anthelmintic activity. Quercetin and Chrysin test samples were prepared in 0.5% SCMC suspension at concentrations of 10, 20, 30, and 40 mg/mL. In each glass beaker containing 25 ml of the aforementioned test samples, six worms (i.e. Pheretima Posthuma) of nearly comparable size (same type) were inserted. The reference standard was albendazole (20 mg/mL), while the control was pure water. Before beginning the experiments, all of the test solutions and standard drug solutions were freshly prepared. The time taken for paralysis turned incited whilst no motion of any type might be determined besides whilst the worms had been vigorously shaken. The time for the worms‘ death was recorded when it was determined that they did not move when shaken vigorously or submerged in warm water (50°C).

Statistical Analysis

All of the findings were put in a Table-1 and expressed as the mean ± standard deviation of six worms in each. Graph Pad Prism 5 version 5.01 was used to analyze the data. A one-way ANOVA test with a confidence interval of 95 percent (p≤0.05) was employed to examine the statistical significance of mean differences.

Evaluation of selected flavonoids and skeletal muscle relaxant activities using animal models.

Experimental animals

The animal experiments were carried out by the institutional guidelines for the care and use of laboratory animals and were approved by the animal ethics committee of KVSR Siddhartha College of Pharmaceutical Sciences (SCOPS), Vijayawada, Andhra Pradesh, India. The National Institute of Nutrition (NIN) in Hyderabad, Andhra Pradesh, India provided male Wistar rats weighing 180-220g. Animals in the KVSRS SCOPS’s animal dwelling were housed in six consistent with cages and provided unrestricted access to food (Hindustan Lever, Mumbai, India) and water. For at least a week before beginning the tests, the animals were housed under typical laboratory settings (12/12 h light/darkness, 22°C, and 50-60% humidity).

Evaluation of skeletal muscle relaxant activity (motor coordination)

After each trial, the animals are strapped to a Rotarod (25 rpm) for 5 minutes or more, as with minor modifications. The rats had been divided into 8 corporations of six. The capsule had been given inside the following order:

- Group I-Control rats (normal saline 10 ml/kg)
- Group II - Standard (diazepam 10 mg/kg)
- Group III - Quercetin 20 mg/kg
- Group IV - Quercetin 40 mg/kg
- Group V-Quercetin 60 mg/kg
- Group VI-Chrysin 20 mg/kg
- Group VII-Chrysin 40 mg/kg
- Group VIII-Chrysin 60 mg/kg

The fall-off time from the rotating rod was measured after a half-hour of management of control, standard, quercetins, and chrysin. The difference in fall-off time from the rotating rod between the control and treated rats was used to determine muscular relaxation.

Evaluation of Locomotor Activity

The spontaneous locomotor activity was assessed using a photoactometer, as described by Idris et al., 2015, with slight changes. Each animal was watched for 5 minutes in a square closed field area (30 cm x 30 cm x 30 cm) with six photocells put on the outer wall. Photocell beam disruptions were recorded using a six-digit counter (locomotor activity). The actophotometer was activated, and each rat was separately placed in the activity cage for 5 minutes to observe the locomotor activity. The baseline activity levels of all of the animals were recorded. After 5 minutes of ingesting the control, standard, quercetin, and chrysin orally, the activity score was calculated. There was a difference in activity before and after the medication was given. The % decrease in motor activity was calculated.

Statistical Analysis

All statistics were computed using the Graph Pad Prism 5.0 program (San Diego, CA). The results were shown as a mean Plus standard deviation. For statistical analysis, the analysis of variance was performed, followed by Dunnett’s multiple comparison tests. P values less than 0.05 have been considered significant.

RESULTS AND DISCUSSION

Evaluation of selected flavonoids for the anthelmintic

According to the findings, chrysin generated a dose-dependent paralytic effect much sooner, and the time to death became shorter for all of the worms shown in Table 1. Quercetin exhibited no paralytic effect at the dosages studied. When compared to quercetin, chrysin exhibited greater potency. Anthelmintic resistance has become a serious concern in recent years as a result of the extensive use of the broad-spectrum anthelmintic medication albendazole, and it has already been detected in livestock. To meet the World Health Organization’s (WHO) global morbidity control targets for helminthiasis, novel anthelmintic drug compounds that are both effective against a broad spectrum of human nematodes and cheap are needed. The current study results reveal that chrysin has substantial anthelmintic activity when compared to albendazole. Albendazole inhibits microtubule-dependent activities such as glucose absorption by inhibiting the polymerization of helminth B-tubulin.
Table 1: Effect of quercetin and chrysin on the paralyzed and death times of earthworms

| Treatment   | Concentration (mg/ml) | Paralyzed Time (min) | Death time (min) |
|------------|-----------------------|----------------------|------------------|
| Control    | -                     | -                    | -                |
| Albendazole| 20                    | 36.3                 | 48.5             |
| Quercetin  | 10                    | Alive                | Alive            |
| Quercetin  | 20                    | Alive                | Alive            |
| Quercetin  | 30                    | Alive                | Alive            |
| Quercetin  | 40                    | Alive                | Alive            |
| Chrysin    | 10                    | 49.6                 | 60.1             |
| Chrysin    | 20                    | 18.4                 | 38.7             |
| Chrysin    | 30                    | 15.5                 | 24.2             |
| Chrysin    | 40                    | 11.2                 | 15.3             |

Table 2: Effect of quercetin and chrysin on the paralyzed and death times of earthworms

| Treatment   | Concentration (mg/ml) | Paralyzed Time (min) | Death time (min) |
|------------|-----------------------|----------------------|------------------|
| Control    | -                     | -                    | -                |
| Albendazole| 20                    | 36.3                 | 48.5             |
| Quercetin  | 10                    | Alive                | Alive            |
| Quercetin  | 20                    | Alive                | Alive            |
| Quercetin  | 30                    | Alive                | Alive            |
| Quercetin  | 40                    | Alive                | Alive            |
| Chrysin    | 10                    | 49.6                 | 60.1             |
| Chrysin    | 20                    | 18.4                 | 38.7             |
| Chrysin    | 30                    | 15.5                 | 24.2             |
| Chrysin    | 40                    | 11.2                 | 15.3             |

Table 3: Effect of quercetin and chrysin on the paralyzed and death times of earthworms

| Treatment   | Concentration (mg/ml) | Paralyzed Time (min) | Death time (min) |
|------------|-----------------------|----------------------|------------------|
| Control    | -                     | -                    | -                |
| Albendazole| 20                    | 33.3                 | 45.5             |
| Quercetin  | 10                    | Alive                | Alive            |
| Quercetin  | 20                    | Alive                | Alive            |
| Quercetin  | 30                    | Alive                | Alive            |
| Quercetin  | 40                    | Alive                | Alive            |
| Chrysin    | 10                    | 41.6                 | 52.1             |
| Chrysin    | 20                    | 18.4                 | 38.7             |
| Chrysin    | 30                    | 17.5                 | 26.2             |
| Chrysin    | 40                    | 15.2                 | 19.3             |
Table 4: Effect of quercetin and chrysin on the paralyzed and death times of earth worms.

| Treatment   | Concentration (mg/ml) | Paralyzed Time (min) | Death time (min) |
|-------------|-----------------------|----------------------|------------------|
| Control     | -                     | -                    | -                |
| Albendazole | 20                    | 31.96±5.13           | 44.6±5.13        |
| Quercetin   | 10                    | Alive                | Alive            |
| Quercetin   | 20                    | Alive                | Alive            |
| Quercetin   | 30                    | Alive                | Alive            |
| Quercetin   | 40                    | Alive                | Alive            |
| Chrysin     | 10                    | 44.26±4.61           | 54.76±4.61       |
| Chrysin     | 20                    | 16.46±3.52           | 36.7±3.46        |
| Chrysin     | 30                    | 14.83±3.05           | 23.53±3.05       |
| Chrysin     | 40                    | 11.86±3.05           | 15.96±3.05       |

Evaluation of selected flavonoids and skeletal muscle relaxant activities using animal models.

Rotarod Test

When compared to the control, chrysin significantly reduced the amount of time the animals spent on the rotating rod (P<0.001). The findings are summarised in [Table 1]. The usual medication (diazepam) showed a significantly significant impact when compared to the control (P<0.001). When compared to the control, three distinct dosages of chrysin (20, 40, and 60 mg/kg) exhibited a dose-dependent increase in muscular relaxation, specifically 193.83 ± 6.62 and 31.00 7.72 after 90 minutes of treatment. At a dosage of 60 mg/kg, chrysin produced the greatest amount of muscular relaxation. The Rotarod test indicated that chrysin decreased the motor coordination of the tested animals considerably. The amount of time spent on the rotating rod was similarly reduced by quercetin, albeit the difference was not statistically significant.

Actophotometer

Locomotor activity research found that chrysin substantially (0 > d) decreased locomotor activity in a dosage and time-dependent manner. The activity intensified as the clock reached 90 minutes. The results are summarised in [Table 2]. After 90 minutes, the percentage of locomotor activity reduction with diazepam (10 mg/kg, p. o.) was 89.87, showing a highly significant (P<0.001) decrease in locomotor activity as compared to the control. At a dosage of 60 mg/kg, chrysin produced the greatest amount of muscular relaxation. None of the three quercetin dosages (20, 40, or 60 mg/kg, p. o.) resulted in a statistically significant reduction in locomotor activity.

Plant flavonoids have prompted a rise in popular and scientific interest in recent years due to their purported health advantages. Flavonoids are specialized metabolites found in plants that comprise big groups of low-molecular-weight polyphenolic chemicals with biological characteristics beneficial to human health. So far, about 5000 distinct flavonoids have been found. According to nutritionists, the typical daily consumption of flavonoids by people on a regular diet is 1-2 g. Flavonoids are naturally occurring polyphenols with hydroxylation and substitution patterns that give birth to several sub-classes including flavanones, anthocyanidins, flavonols, flavones, catechins (or flavanols), isoflavones, dihydroflavonoids and chalcones.

Several in vitro and in vivo investigations have indicated that chrysin possesses anti-disease properties. Chrysin has a wide range of biological and pharmacological activities, including antioxidant, anti-inflammatory, anucancer, neuroprotective, colon protective, nephroprotective, antidiabetic, hypolipidemic, antiarthritic, antiasthmatic, antidepressant, hepatoprotective, cardioprotective, and antiviral properties. Flavonoids show potential as skeletal muscle relaxants. The current investigation discovered that chrysin exhibited muscle relaxant and locomotor depressing effects in experimental animals. Previous studies indicated that the methanolic extract of Basella Alba exhibits antidepressant-like effects as well as skeletal muscle relaxant activity. The action might be attributable to the alkaloids, tannins, and flavonoids present in the leaf extract. Another study indicated that flavonoids and other chemical components in the bark of Acacia nilotica displayed potential centrally and peripherally mediated locomotor depression, skeletal muscle relaxant effects in experimental mouse models.

Table 5. Effect of quercetin and chrysin on muscle relaxant activity in rats

| Treatment     | Fall off time(seconds) before treatment |
|---------------|----------------------------------------|
|               | R1  | R2  | R3  | R4  | R5  | R6  | Mean ±SD     |
| Control       | 196 | 189 | 178 | 190 | 206 | 188 | 191.17±9.30  |
| Diazepam (10mg/kg) | 178 | 161 | 168 | 175 | 159 | 173 | 169.00±7.72  |
| Quercetin (20mg/kg) | 186 | 167 | 176 | 171 | 184 | 169 | 175.50±7.97  |
| Quercetin (40mg/kg) | 193 | 172 | 183 | 191 | 176 | 178 | 182.17±8.42  |
| Quercetin(60mg/kg) | 173 | 154 | 156 | 163 | 170 | 168 | 164.00±7.72  |
| Chrysin(20mh/kg)  | 160 | 177 | 163 | 170 | 180 | 165 | 169.17±7.99  |
| Chrysin(40mg/kg)  | 170 | 185 | 171 | 180 | 187 | 175 | 178.00±7.16  |
| Chrysin60mg/kg)  | 185 | 188 | 202 | 192 | 199 | 197 | 193.83±6.62  |
Table 6. Effects of quercetin and chrysin on muscle relaxant activity in rats after 30 mins of diazepam treatment.

| Treatment               | Fall off time (seconds) before treatment | Mean ±SD       |
|-------------------------|-----------------------------------------|----------------|
|                         | R1 | R2 | R3 | R4 | R5 | R6 |               |
| Control                 | 175 | 174 | 177 | 182 | 191 | 187 | 181.00±6.90   |
| Diazepam (10mg/kg)      | 96  | 94  | 81  | 86  | 77  | 76  | 85.00±8.53    |
| Quercetin (20mg/kg)     | 161 | 175 | 178 | 159 | 168 | 173 | 169.00±7.72   |
| Quercetin (40mg/kg)     | 181 | 179 | 166 | 171 | 162 | 161 | 170.00±8.53   |
| Quercetin (60mg/kg)     | 164 | 159 | 154 | 161 | 144 | 145 | 154.50±8.41   |
| Chrysin (20mg/kg)       | 100 | 110 | 119 | 103 | 120 | 101 | 108.83±8.98   |
| Chrysin (40mg/kg)       | 86  | 106 | 96  | 92  | 89  | 101 | 95.00±7.54    |
| Chrysin 60mg/kg)        | 72  | 92  | 73  | 82  | 78  | 91  | 81.33±8.66    |

Table 7: Effects of quercetin and chrysin on muscle relaxant activity in rats after 60 mins of diazepam treatment.

| Treatment               | Fall off time (seconds) before treatment | Mean ±SD       |
|-------------------------|-----------------------------------------|----------------|
|                         | R1 | R2 | R3 | R4 | R5 | R6 |               |
| Control                 | 184 | 181 | 169 | 174 | 167 | 164 | 173.17±7.99   |
| Diazepam (10mg/kg)      | 34  | 39  | 47  | 29  | 49  | 32  | 38.33±8.19    |
| Quercetin (20mg/kg)     | 164 | 145 | 154 | 162 | 144 | 159 | 154.67±8.57   |
| Quercetin (40mg/kg)     | 180 | 173 | 187 | 190 | 175 | 185 | 181.67±6.80   |
| Quercetin (60mg/kg)     | 158 | 139 | 143 | 141 | 148 | 156 | 147.50±7.97   |
| Chrysin (20mg/kg)       | 52  | 67  | 69  | 73  | 53  | 62  | 62.67±8.64    |
| Chrysin (40mg/kg)       | 45  | 63  | 54  | 47  | 64  | 46  | 53.17±8.61    |
| Chrysin 60mg/kg)        | 40  | 57  | 52  | 47  | 59  | 38  | 48.83±8.70    |

Table 8. Effects of quercetin and chrysin on muscle relaxant activity in rats after 90 mins of diazepam treatment.

| Treatment               | Fall off time (seconds) before treatment | Mean ±SD       |
|-------------------------|-----------------------------------------|----------------|
|                         | R1 | R2 | R3 | R4 | R5 | R6 |               |
| Control                 | 181 | 164 | 180 | 171 | 176 | 162 | 172.33±8.07   |
| Diazepam (10mg/kg)      | 34  | 25  | 18  | 5  | 17 | 35 | 24.00±8.81    |
| Quercetin (20mg/kg)     | 148 | 150 | 131 | 136 | 141 | 132 | 139.67±8.07   |
| Quercetin (40mg/kg)     | 156 | 170 | 165 | 157 | 175 | 158 | 163.50±7.82   |
| Quercetin (60mg/kg)     | 143 | 151 | 160 | 144 | 161 | 146 | 150.83±7.99   |
| Chrysin (20mg/kg)       | 40  | 36  | 45  | 52 | 35 | 55 | 43.83±8.33    |
| Chrysin (40mg/kg)       | 42  | 37  | 25  | 32 | 23 | 37 | 32.67±7.45    |
| Chrysin 60mg/kg)        | 30  | 23  | 35  | 21 | 37 | 40 | 31.00±7.72    |
Table 9: Effect of quercetin and chrysin on muscle relaxant activity in rats

| Treatment       | Fall off time (Mean ± SD) | Percent reduction in fall off time |
|-----------------|---------------------------|-----------------------------------|
|                 | Before treatment          | After 30 min | After 60 min | After 90 min | After 30 min | After 60 min | After 90 min |
| Control         |                          |             |             |             | 191.17±9.30 | 181.00±6.90 | 173.17±7.99 |
| Diazepam 10mg/kg |                          | 169.00±7.72 | 85.00±8.53 | 38.33±8.19 | 24.00±8.81 | 49.704       | 77.319       | 85.798       |
| Quercetin (20mg/kg) |                          | 175.50±7.97 | 169.00±7.72 | 154.67±8.57 | 139.67±8.07 | 3.703        | 11.868       | 20.415       |
| Quercetin (40mg/kg) |                          | 182.17±8.42 | 170.00±7.85 | 181.67±6.80 | 163.50±7.82 | 6.680        | 0.274        | 10.248       |
| Quercetin (60mg/kg) |                          | 164.00±7.72 | 154.50±8.41 | 147.50±7.97 | 150.83±7.99 | 5.792        | 10.060       | 8.030        |
| Chrysin (20mg/kg)  |                          | 169.17±7.99 | 108.83±8.98 | 62.67±8.64 | 43.83±8.33 | 35.668       | 62.954       | 74.091       |
| Chrysin (40mg/kg)  |                          | 178.00±7.16 | 95.00±7.54 | 53.17±8.61 | 32.67±7.45 | 46.629       | 70.129       | 81.646       |
| Chrysin (60mg/kg)  |                          | 193.83±6.62 | 81.33±8.66 | 48.83±8.70 | 31.00±7.72 | 58.040       | 74.80        | 84.006       |

% reduction in fall off time = \( \frac{W_a - W_b}{W_a} \times 100\% \).

Where \( W_a \) and \( W_b \) are the mean fall off times before and after treatment, respectively.

RESULTS WITH ACTOPHOTOMETER

Table 10: Effects of quercetin and chrysin on locomotor activity in rats

| Treatment       | Actophotometer score before treatment |
|-----------------|--------------------------------------|
|                 | R1        | R2        | R3        | R4        | R5        | R6        | Mean ±SD  |
| Control         | 215       | 205       | 208       | 225       | 222       | 204       | 213.17±8.93 |
| Diazepam        | 168       | 171       | 178       | 185       | 188       | 177       | 177.83±7.73 |
| Quercetin (20mg/kg) | 185       | 180       | 177       | 190       | 195       | 175       | 183.67±7.79 |
| Quercetin (40mg/kg) | 170       | 165       | 166       | 180       | 167       | 160       | 168.00±6.72 |
| Quercetin (60mg/kg) | 186       | 487       | 196       | 184       | 206       | 191       | 191.67±8.21 |
| Chrysin (20mg/kg)  | 147       | 154       | 149       | 144       | 148       | 164       | 151.00±7.16 |
| Chrysin (40mg/kg)  | 130       | 125       | 120       | 128       | 140       | 127       | 128.33±6.65 |
| Chrysin (60mg/kg)  | 137       | 145       | 138       | 155       | 147       | 135       | 142.83±7.60 |

Table 11: Effects of quercetin and chrysin on locomotor activity in rats after 30 mins of diazepam treatment.

| Treatment       | Actophotometer score before treatment |
|-----------------|--------------------------------------|
|                 | R1        | R2        | R3        | R4        | R5        | R6        | Mean ±SD  |
| Control         | 182       | 192       | 184       | 202       | 185       | 187       | 188.67±7.37 |
| Diazepam        | 66        | 49        | 56        | 47        | 51        | 46        | 52.50±7.50  |
| Quercetin (20mg/kg) | 168       | 171       | 176       | 178       | 173       | 188       | 175.67±7.00 |
| Quercetin (40mg/kg) | 163       | 147       | 143       | 146       | 153       | 144       | 149.33±7.55 |
| Quercetin (60mg/kg) | 174       | 175       | 194       | 177       | 179       | 184       | 180.50±7.50 |
| Chrysin (20mg/kg)  | 100       | 83        | 88        | 85        | 90        | 87        | 87.50±7.01  |
| Chrysin (40mg/kg)  | 76        | 73        | 84        | 83        | 75        | 93        | 80.67±7.50  |
| Chrysin (60mg/kg)  | 55        | 60        | 65        | 57        | 58        | 75        | 61.67±7.37  |
### Table 12. Effects of quercetin and chrysin on locomotor activity in rats after 60 mins of diazepam treatment.

| Treatment                   | Actophotometer score after 60 mins of treatment | Mean ±SD       |
|-----------------------------|-------------------------------------------------|----------------|
| Control                     | 174 169 167 164 165 184                         | 170.50±7.50    |
| Diazepam (10mg/kg)          | 19 29 20 23 39 25                              | 25.83±7.39     |
| Quercetin (20mg/kg)         | 174 155 164 167 157 154                         | 161.83±7.88    |
| Quercetin (40mg/kg)         | 140 143 152 150 145 160                         | 148.33±7.23    |
| Quercetin (60mg/kg)         | 168 171 188 175 178 172                         | 175.33±7.09    |
| Chrysin (20mg/kg)           | 26 43 29 25 23 33                              | 29.83±7.33     |
| Chrysin (40mg/kg)           | 35 52 38 32 42 37                              | 39.33±7.03     |
| Chrysin (60mg/kg)           | 21 25 24 31 23 41                              | 27.50±7.42     |

### Table 13. Effects of quercetin and chrysin on locomotor activity in rats after 90 mins of diazepam treatment.

| Treatment                   | Actophotometer score after 90 mins treatment | Mean ±SD       |
|-----------------------------|------------------------------------------------|----------------|
| Control                     | 166 161 176 158 156 159                         | 162.67±7.37    |
| Diazepam (10mg/kg)          | 11 21 14 15 31 16                              | 18.00±7.16     |
| Quercetin (20mg/kg)         | 147 149 157 151 137 150                         | 148.50±6.57    |
| Quercetin (40mg/kg)         | 135 138 139 145 147 155                         | 143.17±7.33    |
| Quercetin (60mg/kg)         | 181 164 191 165 171 166                         | 173.00±10.83   |
| Chrysin (20mg/kg)           | 11 14 31 15 17 21                              | 18.17±7.11     |
| Chrysin (40mg/kg)           | 35 20 15 18 25 17                              | 21.67±7.37     |
| Chrysin (60mg/kg)           | 28 11 15 18 20 8                               | 16.67±7.09     |

### Table 14. Effect of quercetin and chrysin on locomotor activity in rats.

| Treatment               | Actophotometer scores (Mean ± SD) | Percent reduction in motor activity |
|-------------------------|------------------------------------|------------------------------------|
|                         | Before treatment | After 30 min | After 60 min | After 90 min | After 30 min | After 60 min | After 90 min |
| Control                 | 213.17±8.93     | 188.67±7.37  | 170.50±7.50  | 162.67±7.37  | 11.52        | 20.01        | 23.69        |
| Diazepam (10mg/kg)      | 177.83±7.73     | 52.50±7.50   | 25.83±7.39   | 18.00±7.16   | 70.47        | 85.47        | 89.87        |
| Quercetin (20mg/kg)     | 183.67±7.79     | 175.67±7.00  | 161.83±7.88  | 148.50±6.57  | 4.30         | 11.88        | 19.14        |
| Quercetin (40mg/kg)     | 168.00±6.72     | 149.33±7.55  | 148.33±7.23  | 143.17±7.33  | 11.11        | 11.70        | 14.82        |
| Quercetin (60mg/kg)     | 191.67±8.21     | 180.50±7.50  | 175.33±7.09  | 173.00±10.83 | 5.82         | 8.50         | 9.70         |
| Chrysin (20mg/kg)       | 151.00±7.16     | 87.50±7.01   | 29.83±7.33   | 18.17±7.11   | 42.05        | 80.24        | 88.01        |
| Chrysin (40mg/kg)       | 128.33±6.65     | 80.67±7.50   | 39.33±7.03   | 21.67±7.37   | 37.14        | 69.35        | 83.12        |
| Chrysin (60mg/kg)       | 142.83±7.60     | 61.67±7.37   | 27.50±7.42   | 16.67±7.09   | 56.82        | 80.7         | 88.33        |
CONCLUSION

The findings of this investigation revealed that chrysin had substantial anthelmintic activity when compared to quercetin and albendazole. As a result, given the development of a novel medication for the treatment of helminthiasis, more study should be extremely beneficial in determining the efficacy of employing chrysin as a new putative anthelmintic therapy.

The findings of this investigation revealed that chrysin has considerable (P 0.001) and dose-dependent muscle relaxant and motor depression action. Quercetin also reduced muscle relaxant and motor activity, but this was not statistically significant.

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Conflict of interest

The authors attest that they have no conflict of interest in this study.

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