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The nutrient profile and *in vivo* anti-inflammatory properties of methanol-extracted turmeric in Wistar rats

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ABSTRACT: *Curcuma longa* has long been recognized for its anti-inflammatory properties in traditional medicine systems, which has received substantial scientific validation. This study aimed to evaluate *C. longa* methanolic extract's proximate and anti-inflammatory activities. Phytochemical screening of *C. longa* was done by colorimetric and spectrophotometric approaches (both qualitative and quantitative respectively). Furthermore, a recent approach (standard method) was used to research *C. longa*'s anti-inflammatory effects and proximate components. The qualitative phytochemical screening revealed a substantial amount of turbid alkaloid (++) but no steroid (-). Phenol (151.34±1.01 mg/100g) had the highest concentration (5.83%), while flavonoid (22.30±0.62 mg/100g) had the lowest (5.83%), according to the quantitative screening. The anti-inflammatory activity of the *C. longa* methanolic extract in the treated groups (150, 300, and 600 mg/kg body weight) and the positive control group demonstrated a valuable value (inhibitory values). Paw thickness was also significantly different (reduced) between the 600 mg/kg (0.7 cm at 6 hours) and positive control groups (0.5 cm at 6 hours) deducing the anti-inflammatory effects of turmeric when compared to the negative control groups. The lowest inhibition was noted in the 150 mg/kg bw group when compared to 1-6 hours of treatment. These findings demonstrated the anti-inflammatory effects of turmeric and its adjuvant capabilities.

Keywords: *Curcuma longa*, inflammation, phytochemical, proximate.

INTRODUCTION

Turmeric is a topic of interest to the scientific, medicinal, and culinary sectors. Turmeric comes from a perennial herbaceous plant called *Curcuma longa*, which belongs to the ginger family (Roy *et al.,* 2022; Mishra *et al.,* 2023). Even though curcumin's health benefits have been known for thousands of years, only recent research has pinpointed its exact mechanism(s) of action and bioactive ingredients (Adamczak *et al.,* 2020). *Curcuma longa* (turmeric) and other *Curcuma* species' rhizomes contain a naturally occurring polyphenol called curcumin, also known as diferuloylmethane. Its chemical name is 1,7-bis(4-hydroxy-3-methoxyphenyl)-1,6-heptane-3,5-dione (Soni *et al.,* 2020). *C. longa* has been used as a medicine in Asian countries for generations due to its antioxidant, anti-inflammatory, antimutagenic, antibacterial, and anticancer properties (Hewlings and Kalman, 2017;

Chandran *et al.,* 2020; Rawat *et al.,* 2021; Mansouri *et al.,* 2020). A polyphenol called curcumin has been shown to target several signaling molecules while also exhibiting cellular activity (Adamczak *et al.,* 2020). It has been demonstrated to be effective in treating pain, metabolic syndrome, and inflammatory and degenerative eye conditions (Zhao *et al.,* 2021; Hasanzadeh *et al.,* 2020; Salehi *et al.,* 2019; Zeng *et al.,* 2021; Liu *et al.,* 2019). It has also been demonstrated to be beneficial for the kidneys (Rapa *et al.,* 2019). While curcumin supplementation appears to provide a variety of therapeutic benefits, the majority of these are related to the anti-inflammatory and antioxidant properties of the compound (Adamczak *et al.,* 2020; Zhao *et al.,* 2021). Although curcumin is thought to have anti-inflammatory and antioxidant properties, one of its biggest drawbacks when taken alone is that it has a low absorption (Kotha and Lutria, 2019).

It is thought that inflammation is a sophisticated biological process that causes tissue homeostasis to break down. Numerous biological, pharmacological, or physical stressors can cause inflammation, and depending on the stimulus, it may be acute or chronic. An inflammatory cascade that can lead to a range of disorders, including chronic asthma, rheumatoid arthritis, inflammatory bowel disease, and psoriasis, is triggered when the immune system's persistent attempts to reverse the detrimental effects of acute inflammation are unsuccessful (Jiang *et al.,* 2020). Chronic infections and inflammation have been revealed to be important cancer risk factors in experimental research and clinical epidemiological data (Yang *et al.,* 2020). In the past, it was thought that underlying infections and inflammatory reactions were responsible for 15–20% of all cancer-related deaths (Yang *et al.,* 2020; Soy *et al.,* 2020). While many different therapeutic modalities, such as corticosteroids, nonsteroidal anti-inflammatory medications (NSAIDs), and biologic medicines, are routinely used to treat inflammation, they are both costly and have several side effects. To decrease the downsides of both synthetic and biological medications, phytocompounds derived from diverse medicinal plants have been used as viable replacements. Significant research on medicinal plants supports the notion that plant extracts can be used as therapeutic agents due to many components' synergistic and cumulative effects (Hariharan *et al.,* 2021). This study aims to clarify the relationship between the proximate and anti-inflammatory capabilities of turmeric because there are few records of it.

MATERIALS AND METHODS

Authentication and collection of samples

The turmeric (*Curcuma longa*), which was purchased in February 2021 from the Kure market in the Bosso Local Government Area of Niger State, Minna, Nigeria was confirmed for its safe use in research by the Department of Plant Biology at the Federal University of Technology in Minna with batch number 00020.

Animals used

The rats used in the investigation on inflammation were donated by the National Institute for Research in Kaduna State, Nigeria. The rats, whose weights ranged from 154.89±3.45 g, had a week of acclimation at FUTMINNA's Animal Housing Unit, Department of Biochemistry, before being used. All animal experiments were carried out according to recognized guidelines for the treatment of lab animals.

Ethical considerations

The experimental protocol was approved by the Animal Care and Ethics Committee of the Federal University of Technology in Minna and was by guidelines provided by the Nigerian National Health and Medical Research Council.

Preparation of *C. longa*

The fresh turmeric sample was cleaned, divided into slices, and dried for about five (5) days in the open air before the top layer was removed. Using an electric blender, the dried turmeric was ground into a powder. Before the extraction process, the crushed turmeric was cooled (Guimaraes *et al.,* 2020).

C. longa extract preparation

1.5 liters of methanol were added to two 1-liter beakers that held 1.5 grams of dried turmeric each. The two beakers were then covered with aluminum foil or paper and let stand for 72 hours. After 72 hours, the mixture was strained through filter paper and heated to 47 degrees Celsius to remove the methanol from the extract (Glavinic *et al.,* 2021). Following that, the extract was weighed, quantified, and saved for later analysis.

Inoculum preparation

An uncooked chicken egg was used to create an egg albumin solution. A 0.1 mL solution made from egg albumin (the egg's white after it's been cracked) and distilled water was utilized to incite inflammation in albino rats. The solution's concentration was set at 1% (Anosike *et al.,* 2012).

Phytochemicals screening of *C. longa*

The methods for screening phytochemicals utilized in this work were discussed by Salem *et al.* (2021), Yau *et al.* (2020) and Waheed and Benjamin (2021) and others. To ascertain whether phytoconstituents were present in the turmeric powder sample, examinations were carried out by the Center for Genetic Engineering and Biotechnology, Federal University of Technology, Minna, Nigeria.

Qualitative analysis of *C. longa*

Tannin analysis

Two milliliters of the extract and two milliliters of the 10% alcoholic ferric chloride were mixed. Tannin was present as indicated by the dark blue color (Anand *et al.,* 2022).

Steroid test

2 mL of acetic anhydride and 2 mL of sulfuric acid were added to 1 mL of the extract. Steroids were present because the extract's colour altered from blue to a dark green shade (Mahendran and Rahman, 2020).

Flavonoid detection

10 mL of ethyl acetate was added to a 10 g extract, which was then cooked in a water bath for 5 minutes at 50 degrees Celsius. After adding 1 mL of diluted ammonia to the filtrate, a yellow tint appeared, suggesting that the test for flavonoid was successful (Abubakar and Haque, 2020).

Terpenoid analysis

A mixture of 5 mL of the extract, 3 mL of sulfuric acid, and 2 mL of chloroform were added. The combination formed a layer, and the appearance of a reddish-brown color showed the existence of terpenoids (Mahendran and Rahman, 2020).

Saponin test

20 mL of distilled water and 2 g of the extract were heated in a water bath at 45 °C. Following a filtering process, the mixture was mixed with 5 mL of distilled water to make 10 mL of the filtrate. An emulsion formed after the liquid was violently shaken and 3 drops of olive oil were added to the stable foam, indicating that the saponin test was successful (Mahendran and Rahman, 2020).

Alkaloid detection

A 1-gram extract was mixed with 5 mL of 2N hydrochloric acid and 5 mL of methanol. The mixture was filtered, and the filtrate was then treated with Meyer's and Wagner's reagents. Turbidity suggested a positive alkaloid test result (Abubakar and Haque, 2020).

Phenol analysis

When 2 mL of phenol extract and 1 mL of ferric chloride were mixed, a reddish-brown color emerged, showing the presence of phenol, however, it was not a strong or deep colour (Sankhalkar and Vernekar, 2016).

Ascorbic test

A 2 mL of the extract, which contained 2% by weight of ferrous sulfate, sodium bicarbonate (0.1 g), and purified water were combined. After giving the combination a good shake, it was given a brief period to stand. The presence of 5 mL of 1 M sulfuric acid resulted in the appearance of a dark violet color, which then vanished. The disappearance of the violet hue revealed the presence of ascorbic acid in the sample (Sathelly *et al.,* 2022).

Free reducing sugar detection

A crimson cuprous oxide precipitate formed when Fehling reagent was applied to 1 mL of turmeric extract, indicating that the test for free reducing sugar was effective (Song *et al.,* 2020).

Quantitative analysis of *C. longa*

Phenol determination

A 0.1 g of turmeric extract was mixed with 10 mL of distilled water. In addition, 0.5 mL of the extract solution was oxidized using 2.5 mL of the 10% Folin-Ciocalteau reagent. Next, 2 mL of sodium carbonate solution at 7.5 percent was used to neutralize it. The mixture was incubated for 40 minutes at 45 degrees Celsius. The absorbance at 765 nm was then measured using a UV-spectrophotometer (UV-1800) (Khadiri *et al.,* 2023).

Saponin test

0.5 g of the extract was dissolved in 20 mL of 1N HCl, and the mixture was then heated for 4 hours in a water bath. But after filtering and letting the liquid cool, 50 mL of petroleum ether was added. The supernatant was combined with 6 mL of ferrous sulfate, 2 mL of H_2SO_4, and 5 mL of acetone: ethanol, and left to stand for 10 minutes

after being evaporated (1:1). After that, the absorbance at 490 nm was discovered using a UV spectrophotometer (Wadekar *et al.,* 2021).

Tannin analysis

0.2 grams of extract were dissolved in 20 mL of 50% methanol, which was then parafilm-wrapped and heated for an hour in a water bath at 80 degrees Celsius. After filtering the mixture, 20 mL of Deni's distilled water, 10 mL of sodium carbonate, and 2.5 mL of Folin-reagent were added. After giving the mixture a good shake, it was allowed to develop a bluish-green hue for 20 minutes. A UV spectrophotometer (UV-1800) was used to measure the absorbance at 760 nm (Fatima *et al.,* 2018).

Flavonoid determination

A 0.5 mL of the extract was mixed with 0.1 mL of 1 M sodium acetate, 0.1 mL of pure methanol, 1.5 mL of the extract, 2.8 mL of distilled water, and 0.1 mL of 10 percent aluminum chloride. A 30-minute room-temperature incubition time came next. Utilizing a UV spectrophotometer with a wavelength of 415 nm, the absorbance was measured (Kim *et al.,* 2021).

Alkaloid test

Before filtering using Whatman No1 filter paper, a 0.5 g extract was diluted in 5 mL of a 1:1 solution of 96 percent ethanol and 20 percent H_2SO_4. 1 mL of the filtrate was then allowed to stand for 5 minutes before being combined with 5 mL of 60 percent H_2SO_4. After 5 minutes, 5 mL of 0.5 percent formaldehyde was added, and it was allowed to rest at room temperature for 3 hours. A UV spectrophotometer was used to detect the absorbance at 565 nm (Wadekar *et al.,* 2021).

Proximate analysis of raw *C. longa*

Moisture content determination

Using the oven drying procedure, the moisture content was determined by precisely weighing 2 g of well-mixed material in a cleaned, dried moisture container (W_1). The moisture container containing the sample was heated to 103.5°C for 4-5 hours to ensure a constant weight. The can was then allowed to cool in the desiccators for 30 minutes. After cooling, it was weighed a second time (W_2). El-Mougy *et al.* (2009), Thiex (2009) and AOAC (2005) stated that the formula for calculating the percentage (%) moisture is as follows:

$$\%\ Moisture = \frac{W_1 - W_2}{Wt\ of\ Sampl}\ x\ 100$$

Where: W_1 = Initial weight of can + Sample, W_2 = Final weight of can + Sample.

Determination of total ash content

After being cleaned and heated to 600°C for an hour in a muffle furnace, an empty crucible was weighed. Desiccators were used to reduce the temperature (W_1). Each sample weighed 2 g, which was put in a crucible. A blowpipe was used to burn the sample over a burner. The crucible was then heated to 600°C in a muffle furnace for three hours. The sample's organic makeup has completely oxidized, as evidenced by the presence of gray-white ash. The ashing furnace was then turned off. After cooling in desiccators, the crucible was weighed (W_3). The following calculation was used to determine the percentage of ash (Thiex, 2009):

$$\%\ Ash = \frac{Difference\ in\ Wt\ of\ Ash}{Wt\ of\ Sampl}\ x\ 100$$

The difference in wt. of Ash = W_3 - W_1

Crude protein test

Protein in the sample was determined by the Kjeldahl method. 0.5-1.0 g of dried sample was taken in a digestion flask. Add 10-15 ml of concentrated H_2SO_4 and 8 g of digestion mixture i.e. K_2SO_4:$CuSO_4$ (8:1). The flask was swirled to mix the contents thoroughly then placed on the heater to start digestion till the mixture became clear (blue-green color). After chilling, the liquid was transferred to a 100 mL volumetric flask, and the required volume of distilled water was added. The digest was distilled using the Markam Still Distillation Apparatus. Following an additional 10 minutes of distillation, the NH_3 generated up to 75 mL was collected as NH_4OH in a conical flask with 20 mL of a 2 percent boric acid solution and a few drops of methyl red and bromo-cresol green indicator. The NH_4OH causes the distillation to have a yellow tint. The distillate was titrated with conventional 0.01N HCl solutions until a pink tint appeared. All the earlier steps were performed with a blank as well. The sample's crude protein content was calculated using the formula below (Gul and Safdar, 2009):

$$\%\ N = \frac{(S - B)x\ N\ x\ 0.014\ x\ D}{Wt\ of\ the\ Sample\ x\ V}\ x\ 100$$

% Crude Protein = 6.25* x %N (*Correction factor)

Where: S = Sample titration reading, B = Blank titration

reading, N = Normality of HCl, D = Dilution of the sample after digestion, V = Volume taken for distillation, 0.014 = Mill equivalent weight of Nitrogen.

Crude fat content analysis

Crude fat content was computed using an intermittent Soxhlet extraction device. Crude fat was detected using the ether extract method and the soxlet equipment. A 2 g dry sample was inserted into the extraction tube after being placed in a fat-free thimble and coated with filter paper. The round bottom flask was placed into the apparatus after it had been dried, weighed, and filled with petroleum ether. The extraction took 6 hours to complete. The ether was then allowed to vanish. For ether cleaning, the extract was transferred to a fresh glass dish, and the ether was then evaporated over a water bath. It was then baked for 30 minutes at 105°C before being placed in a desiccator. The following formula was used to determine the crude fat percentage (Chinma *et al.,* 2021; Thiex, 2009).

$$\%\text{Crude fat} = \frac{\text{Wt of flask with oil} - \text{Wt of empty flask}}{\text{Wt of sample}} 100$$

Determination of carbohydrate content

The difference was used to determine the sample's carbohydrate content. The carbohydrate content is the sum of all previously determined proximate factors deducted from 100 (Thiex, 2009).

100 – (%Moisture content + %Ash Content + %Crude fiber + %Crude protein + %Crude fat).

In vivo screening for inflammatory activity

The method described by Agarwal *et al.* (2019) was used to investigate the anti-inflammatory effects of the methanol extract of turmeric.

Infection of animals

The inoculums, which were artificial egg albumin at 1%, were administered to all the experimental rats to elicit inflammation. 0.1 mL of the egg albumin solution was injected intraperitoneally into each rat (Sanchez-Maeto *et al.,* 2006), weighing between 105.94 and 183.17 g.

Administration of extract to infected rats

Using the methodology outlined by Sanchez-Maeto *et al.* (2006), the anti-inflammatory effect of the methanol extract of turmeric was studied. Fifteen (15) healthy albino rats were divided into five (5) groups of three (3) each. The positive and negative control groups received distilled water and sodium diclofenac (100 mg/kg body weight; from a stock solution of 50 mg/mL), respectively. Groups 1, 2, and 3 received oral dosages of 150, 300, and 600 mg/kg bw of methanolic turmeric extract (100 mg/mL), respectively. This was completed an hour before all of the rats' right hind paws were administered intraperitoneally with 0.1 mL of prepared, 1 percent egg albumin to induce inflammation. The back paw started to swell and turn red after around 40 minutes. The thickness of the injected paw was then measured at 0, 1, 2, 3, 4, and 6 hours following the injection of egg albumin using a vernier caliper (Agarwal *et al.,* 2019).

Level of inflammation in rats

The thickness of the paws of Wistar rats that had been administered egg albumin to excite them was tested to ascertain the effects of turmeric methanol extract. This was accomplished by utilizing a vernier caliper, as described by Agarwal *et al.* (2019). Rat paws were placed on the vernier caliper, and the quantity of edema and redness was properly measured. The procedures for handling experimental animals were followed during this.

Analysis of data

Bar graphs and analysis of variance (ANOVA) were used to analyze the results of the analysis. The connection between the mean variables was evaluated using the Duncan test. The outcomes were also shown in tables as Mean Standard Deviation. Version 23 of IBM SPSS (Statistical Package for Social Science) was used to carry out the investigation. While p values of 0.05 or lower were not considered statistically significant, those of 0.05 or higher were.

RESULTS

Percentage yield of *C. longa* extract

Table 1 shows the yield of *C. longa*'s aqueous extract as a percentage. From a sample of 150 g of garlic, 10.72 g of extract was obtained, or 7.15% of the total extract.

Qualitative phytochemical screening of *C. longa*

The phytochemical results of the *C. longa* methanol extract is displayed in Table 2. Some chemicals are absent, whereas others are either weakly present or extremely concentrated.

Table 1. Yield of methanol extract of *C. longa* in percentage (%).

Plants	Powdered *C. longa* (g)	Extract yield (%)
Turmeric	150	7.15

Table 2. Qualitative phytochemical analysis of *C. longa.*

Phytochemicals	Status/ Results	Inferences
Tannin	+	Dark-blue color
Ascorbic acid	-	Violet to colorless
Alkaloid	++	Turbidity present
Saponin	+	Froth emulsion
Reducing sugar	-	Red precipitate
Terpenoid	+	Reddish-brown color
Flavonoid	+	Yellow color
Steroid	-	Blue to dark green color
Phenol	+	Red-brown color

Keys: (-) means absent, (+) means present, (++) means highly present.

Table 3. Quantitative phytochemical analysis of *C. longa.*

Phytochemicals	Results(mg/100g)	Percentage (%)
Phenol	151.34±1.01^{e}	39.54
Saponin	145.11±1.79^{d}	37.94
Tannin	35.50±1.19^{c}	9.28
Flavonoid	22.30±0.62^{a}	5.83
Alkaloid	28.26±1.05^{b}	7.39

Values represent the mean and standard deviation of three independent determinations. $p<0.05$ denotes superscripts with various values within the same columns (significantly different).

Table 4. Proximate compositions of methanol extract of *C. longa.*

Parameters	Turmeric sample (%)
Moisture content	11.35±0.05
Ash content	3.50±0.05
Protein content	5.26±0.04
Fiber content	1.31±0.05
Lipid content	5.62±0.13
Carbohydrate.	73.42±0.18

Values represent the mean and standard deviation of three independent determinations. $p<0.05$ denotes superscripts with various values within the same columns (significantly different).

Quantitative phytochemical screening of *C. longa*

The results for the amount of phytochemicals found in the *C. longa* methanol extract as well as the % amount for each parameter are shown in Table 3. The results showed that phenol had the highest concentration of 151.34 mg/100 g (39.54%) and flavonoid had the lowest value of 22.30 mg/100 g (5.83%).

Proximate analysis of *C. longa* extract

The results of the proximate components of the *C. longa* extract sample are displayed in Table 4.

Anti-inflammatory activity of *C. longa* extract

Paw thickness measurement

Figure 1 displays the findings of paw thickness measurement performed using a caliper. When compared to the treatment groups and the positive control group, there was a statistically significant decrease in swelling in the treatment groups (150, 300, and 600 mg/kg bw), while the infected but untreated group showed a significant increase ($p<0.05$).

DISCUSSIONS

The preliminary phytochemical screening results offer an empirical justification for the use of therapeutic plants in conventional medicine (Lourenco *et al.,* 2019). The amount of *C. longa* extract (10.7 g) used in this investigation was equal to the 7.15 percent methanol extract that 150 g of powdered *C. longa* produced (Table 1). This was computed by dividing the weight of the *C. longa* powdered (150 g) by the weight of the acquired extract, which weighed 10.72 g. This is comparable to Sawant and Godghate (2013) research which used the Soxhlet extraction method to obtain a 9% yield from a 40 g powdered *C. longa* rhizome sample.

Tannins (+), phenol (+), and other phytochemicals were discovered during the qualitative phytochemical screening. With phenol having a high concentration (++) and other compounds having a lesser concentration (+), the alkaloid test revealed very deep turbidity (Table 2). According to Sawant and Godghate (2013) study, phytochemical screening of turmeric methanolic extract showed the presence of alkaloids, tannins, phenolic compounds, terpenoids and phytosterols, saponins, and flavonoids. The steroid test's colour changed from blue to dark green, while the ascorbic acid test's colour changed from violet to colorless, all of which indicated a positive result. In the study conducted by Madaki *et al.* (2022), the analysis of the aqueous extract of garlic revealed the presence of phytochemical components such as alkaloids, flavonoids, tannins, saponins, glycosides, terpenoids, and ascorbic acid. However, the study did not detect steroids and reducing sugars. Additionally, Salem *et al.* (2021), and Jemal *et al.* (2022), both offered a typical technique for

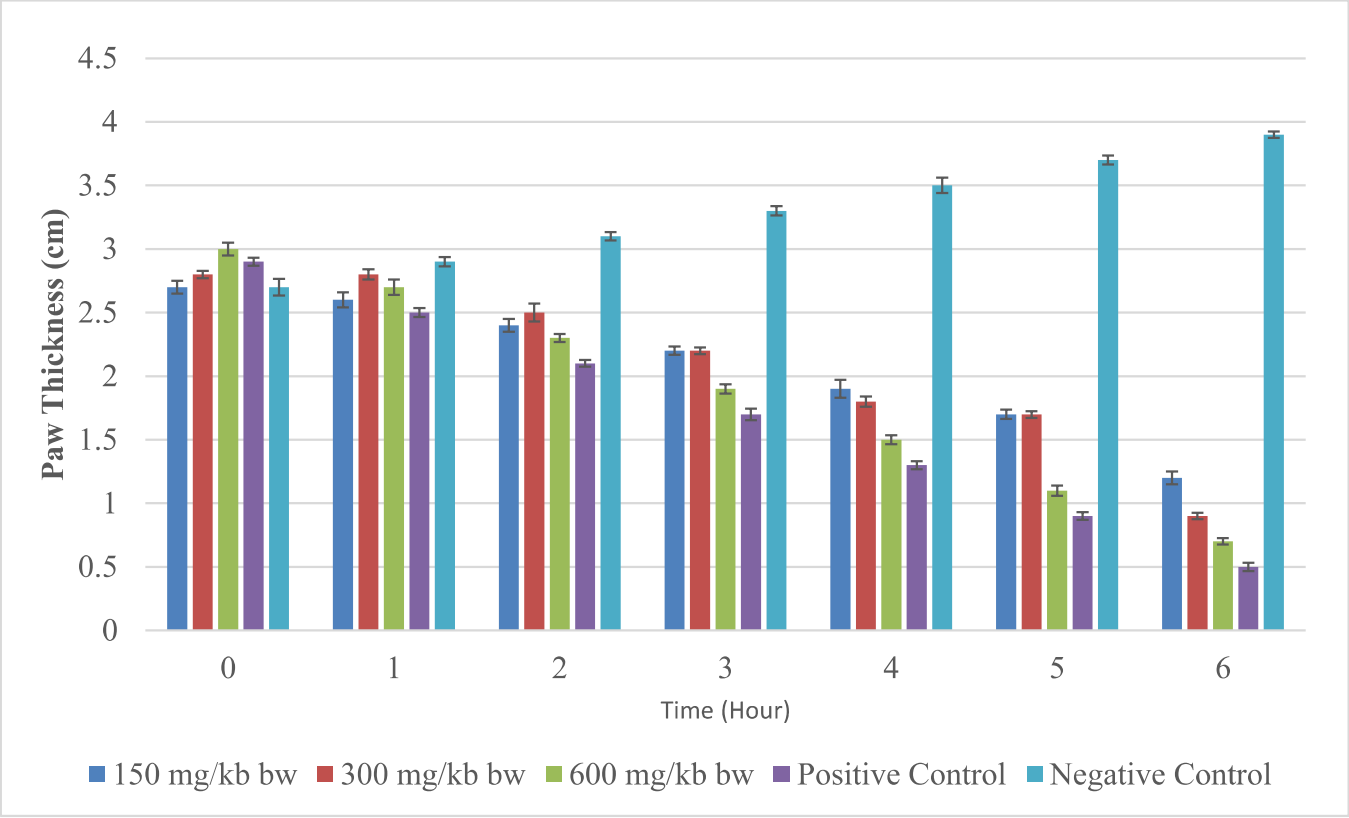

Figure 1. Effects of *C. longa* methanol extract on paw thickness of infected rats.

doing so. The data that follow are based on research by Az-Zahra *et al.* (2020), who detected flavonoids and tannins in an ethanol extract of turmeric. Studies carried out in Ilorin and Kano that discovered cardiac glycosides, flavonoids, saponins, tannins, and alkaloids from the turmeric plant revealed comparable results for *Curcuma longa* Linn root (Alelign *et al.,* 2020; Shokunbi *et al.,* 2023).

Although secondary plant metabolites known as phytochemicals are known to be vital to both plants and animals, especially when taken in large quantities, they may also be detrimental or have deleterious effects on animals, which is why they are referred to as anti-nutrients (Batool *et al.,* 2023). In the quantitative phytochemical analysis, phenol had the highest concentration of phytochemicals (151.34±1.01 mg/100 g) and flavonoid had the lowest concentration (22.30±0.62 mg/100 g). This is like the work of Madaki *et al.* (2022) whose data revealed the highest concentration of phenol at 291.88 mg/100g and the lowest concentration of alkaloids at 13.66 mg/100g. According to Oklo *et al.* (2023) quantitative investigation, the methanol extract of turmeric has a higher proportion of secondary metabolites than the aqueous extract and n-hexane extract. Of the total parameters evaluated in Table 3, flavonoids and phenol were found at 5.83 percent and 39.54 percent, respectively. Saponins may serve as a key precursor for steroidal compounds and have been documented to have antibacterial properties. These steroidal drugs have a variety of pharmacological effects (Ramzan and Zeshan, 2023). According to Table 3, saponin made up 37.94% of the total, whereas alkaloid and tannin made up 7.39 and 9.28%, respectively. The examined traits did, however, differ significantly from one another ($p>0.05$). Some proteins can precipitate because of tannins. They interact with digestive enzymes, rendering them indigestible (Kuncari, 2023). Alkaloids are active against bacteria. Three pharmacologically significant curcuminoids from the Curcuma longa plant include curcumin, dimethoxy curcumin, and bis-dementia-hydroxy curcumin (Gangal *et al.,* 2023). Hence, most medicinal plants' biological and pharmacological effects are caused by their phytochemical components (Uthayarasa *et al.,* 2010).

An alkaline environment, which is produced by consuming meals with a high ash content, is essential for overall health (McClements, 2015). The *Curcuma longa* extract has an ash concentration of 8.70%, which affects all living cells in our bodies, as well as a pH level that impacts fluid distribution (Oklo *et al.,* 2023). Table 3 provides a close proximate study of turmeric extract. The parameters moisture content, ash content, crude fiber, and

crude protein were among those looked at. The bulk (73.42±0.18 percent) of the metrics examined were carbohydrates, while fiber accounted for the least proportion (1.31±0.05 percent). According to Oklo *et al*. (2023), crude fat of 4.25% was found in *Curcuma longa* methanol extract. The crude fat content of *Curcuma longa* Linn may significantly increase food's caloric value, slow down the absorption of carbohydrates, and lubricate the intestines (Bleakley and Hayes, 2017; Oklo *et al.,* 2023). Ash, moisture, and lipid content were all calculated to be in the range of 11.35±0.05, 3.50±0.05, and 5.62±0.13 percentage in this study, respectively. According to research by Oklo *et al.* (2023), 15% of *Curcuma longa's* moisture content was observed, indicating the plant has a long shelf life and is extremely succulent. Consuming dietary fiber has been linked to several physiological effects, including an increase in fecal volume, a decrease in plasma cholesterol, a blunting of the post-meal rise in blood sugar, and a reduction in the bioavailability of nutrients (Daou *et al.,* 2014).

Researchers have discovered that *Curcuma longa* extracts contain antioxidant, anti-inflammatory, anti-mutagenic, anti-carcinogenic, anti-fungal, anti-viral, and anti-cancer effects (Fahed *et al*., 2022; Lourenco *et al*., 2019; Abuga *et al*., 2022). There is a statistically significant difference between the treatment and control groups in Figure 1 ($p<0.05$). From the first hour to the final hour (six) of recording, the rat paw thickness (swellings) in the negative control group increased steadily. The treated and untreated groups did not differ substantially after 1 hour ($p<0.05$), whereas the 600 mg/kg body weight, positive, and negative control groups did not differ significantly at 0 hours ($p>0.05$) (Figure 1). Superoxide dismutase, glutathione, and glutathione reductase enzyme levels in blood and glutathione-S-transferase and superoxide dismutase enzymes in the liver were all enhanced in mice after receiving turmeric oil orally for a month (Razavi *et al.,* 2021). Carrageenan-induced acute inflammation, dextran-induced chronic inflammation, and formalin-induced acute inflammation were all significantly reduced by turmeric oil (Razavi *et al.,* 2021). The treatment groups (150, 300, and 600 mg/kg bw) also experienced small declines, with the 600 mg/kg bw group showing the most decline in paw thickness. This is consistent with the findings of Shahzad *et al.* (2020), who found that all tested doses (90, 180, and 360 mg/kg b.w.) were significantly lower when compared to the vehicle control group. The fact that there was a considerable drop in 600 mg/kg body weight also supports the idea that methanol extract treatment of inflammation is dose-dependent. In hours 0 through 4, there was no significant difference ($p>0.05$) between the 600 mg/kg body weight and positive control groups. However, in hours 5 and 6, there was a significant difference ($p<0.05$) as seen in Figure 1.

Curcumin is a powerful indicator of the action of curcuminoids as powerful anti-inflammatory agents. This is because of its chemical composition, which also includes nine other steric interactions and two methoxy active groups (-OCH_3) that can bind to receptors via steric interactions (Tyr385, Leu531) (Meizarini *et al.,* 2018). Reduced paw thickness in groups receiving lower doses of the turmeric extract—150 and 300 mg/kg bw—could be the result of an insufficient dose, poor absorption, or-more crucially-a postponed start to therapy. The phytochemical components are also determined by the solvents utilized. When compared to the least polar solvents, more polar solvents have fewer components (Abu-Almaaty *et al.,* 2021). Traditional medicine uses turmeric a lot (Makhuvele *et al.,* 2022). The scientific phytochemical screening can provide a good scientific explanation for its usage in addressing different diseases (Sawant and Godghate, 2013; Das *et al.,* 2023).

Conclusion

C. longa has attracted attention from all around the world due to its natural benefits. The analysis found that turmeric's anti-inflammatory activity was dose-dependent as a result of its nutritional composition and phytoconstituents (bioactive compounds). The analysis found that turmeric is both healthful and a respectable source of carbohydrates. It is recommended to begin treatment before the condition progresses to a chronic stage and to adjust the dosage as necessary. Since the high anti-inflammatory activity was observed at 600 mg/kg body weight as found in the positive control group, it is proposed that more scientific research be done on other turmeric plant components such as roots, stems, leaves, etc. for effective anti-inflammatory action.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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