



Antinociceptive and Anti-inflammatory Properties of *Triumfetta cordifolia* A. Rich. (*Tiliaceae*) Root Methanol/Dichloromethane Extract

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Objective: *Triumfetta cordifolia* is a terrestrial plant of the Tiliaceae family used traditionally for the treatment of many diseases. Different parts are traditionally used for the treatment of diseases that cause pain and inflammation. This study aims to evaluate the antinociceptive and anti-inflammatory activities of the methanol/dichloromethane extract of *T. cordifolia* roots in animal models.

Methodology: Phytochemical screening and the toxicity study of methanol/dichloromethane extract of *Triumfetta cordifolia* roots were performed. Antinociceptive activity was evaluated using acetic acid and formalin tests. *In vitro* anti-inflammatory activity was evaluated using the bovine serum albumin (BSA) denaturation method and *In vivo* on carrageenan-induced oedema. The extract was given orally at doses of 50, 100 and 150 mg/kg of body weight.

Results: The phytochemical analysis revealed the presence of alkaloids, saponins, flavonoids, polyphenols, reducing sugars, tannins, coumarins and steroids. No signs of toxicity were observed after 14 days experiment. Regarding antinociceptive activity, *Triumfetta cordifolia* (200 mg/kg) has decreased significantly ($P < 0.0001$) the number of abdominal contortions and also significantly inhibited the formalin-induced neurogenic pain at the dose of 50 mg/kg body weight. In anti-inflammatory tests, the extract inhibited oedema ($P < 0,001$) at 50mg/kg at the fourth hour and also protected the serum albumin bovine denaturation ($P < 0.05$) at a concentration of 50 $\mu\text{g/ml}$.

Conclusion: The results obtained indicate that the methanol/dichloromethane extract is without acute toxicity and has peripheral and central analgesic properties, as well as anti-inflammatory properties *In vivo* and *In vitro*.

Keywords: *Triumfetta cordifolia*; methanol/dichloromethane extract; analgesic; anti-inflammatory; phytochemical screening; toxicity.

1. INTRODUCTION

Pain is defined as an unpleasant sensory and emotional experience associated with or resembling of actual or potential tissue damage [1]. Pain can play a protective role, as is the case of acute inflammation which results in the perception of pain, leading to the avoidance of harmful stimuli and the encouragement of tissue healing [2]. Inflammation is defined as a process of immune defence of the body in response to a stimulus with endogenous or exogenous origin, which can be transmitted through infection, trauma, surgery, burns or necrotic tissue [3]. Painful and inflammatory conditions are a major health, social, and economic problem. According to the International Association for the Study of Pain (IASP) criteria, the prevalence of chronic pain ranges from 15 to 35% in the global population. Approximately 1.71 billion people worldwide live with osteoarticular disorders such as low back pain, osteoarthritis, trauma, and rheumatoid arthritis [4]. Pain and inflammation are ailments that can cause significant physical/moral suffering, responsible for the major alteration in the quality of life of patients. Therefore, regardless of the origin, painful and inflammatory conditions must be managed. In conventional medicine, the World Health Organization (WHO) recommends the use of analgesics (non-opioids weak opioids, and strong opioids) and anti-inflammatory drugs as a

treatment. However, their use exposes the patient to many risks and side effects. The risks encountered are gastric ulcers, kidney failure, withdrawal syndrome, and addiction [5].

The use of plants in herbal medicine dates back to antiquity and has grown with the evolution of civilization in all regions of the world. Plants have always held an important place in medicine. They are considered an essential source of raw material necessary for the discovery of molecules useful in the manufacture of new drugs [6]. *Triumfetta cordifolia* is a species of the Tiliaceae family whose decocted leaves and macerated bark are used to treat lumbago and muscle pain [7]. The plant is consumed in western Cameroon as a traditional meal named "Nkui" [8]. HPLC analyses of methanol extract of *T. cordifolia* leaves collected in Bayelsa State, Nigeria, showed that kaempferol was the major flavonoid compound, followed by quercitrin, (+) catechin, luteolin, quercetin, apigenin, rutin and myricetin [9]. Moreover, the plant extract possesses a notable anti-inflammatory effectiveness against formalin-induced paw edema [9]. This research was carried out to increase the literature on the anti-inflammation properties by confirming their traditional use in the treatment of pain. The analgesic and anti-inflammatory properties of the methanol/dichloromethane extract of the roots of *T. cordifolia* are described.

2. MATERIALS AND METHODS

2.1 Chemicals Used

Paracetamol 500 mg (Ubigen Laboratory), acetic acid 1%, formaldehyde 1%, Tramadol 50 mg (Tramadol^R 50 mg Cooper Laboratory), BSA (bovine serum albumin) 4%, PBS buffer at pH 6.6, carrageenan 1%, diclofenac 10 mg/kg (Ubigen Laboratory).

2.2 Plant Material

The roots of *Triumfetta cordifolia* (Fig. 1) were collected in October 2021 in the commune of Bonaléa, canton of Abo south; village of Penda Mboko in Moungo Department, Littoral region, Cameroon. The identification was made at the National Herbarium of Cameroon, in comparison with the material of Breteler N° 515 of the specimens of the Herbarium Collection N° 10792 SRF Cam.

2.3 Preparation of the Extract

After harvest, the fresh roots (2200g) of *T. cordifolia* were cleaned and ground to obtain the dough. The dough obtained was macerated three times in the mixtures of methanol /dichloromethane (70 / 30) for 72 hours at room temperature. After filtration, the filtrate was concentrated to obtain 59.9 g (yield: 2.72%) of crude extract.

2.4 Animals

Wistar albino rats aged 50 -70 days, weight 95 - 115 g were used for the acute toxicity test; rats aged of 60 - 90 days, 120-180 g for anti-inflammatory activity and *Swiss* mice (aged 70 -

100 days, 19 and 32 g) for analgesic tests. The animals were raised in the animal facility of the Faculty of Medicine and Pharmaceutical Sciences of Douala in plastic cages, under normal conditions of temperature (23-30 °C) and alternation 12 h of light /dark cycle. They had free access to water and food.

2.5. Evaluation of Acute Toxicity Assessment

The acute toxicity assessment of the extract was conducted using the protocol for the limit test proposed by the Organization for Economic Cooperation and Development (OECD) guidelines number 425 (2008) [10]. The study was carried out over 14 days in 9 female *Wistar* rats. After five-day acclimatization animals were fasted for 12 hours with free access to water prior to the study and distributed as follows: control batch consisting of 3 females receiving distilled water (10 mL/kg); two experimental batches of three females each receiving a single dose of extract dosed at 2000 mg/kg and 5000 mg/kg by oral route. Animals were observed for mortality and clinical signs of toxicity such as respiration, faecal consistency, aspects of the coat, diarrhoea, vomiting, tremors, tachycardia, unrest, convulsions/coma/death during 3 hours after administration of the extract. After those first hours of observation, the rats were further monitored daily for their body weight as well as their mortality over a period of 14 days. At the end of the experiment, the rats were sacrificed under anaesthesia with ether solution and internal organs such as the liver, kidneys, lung, heart and spleen were removed, cleaned, weighed, and macroscopically observed.

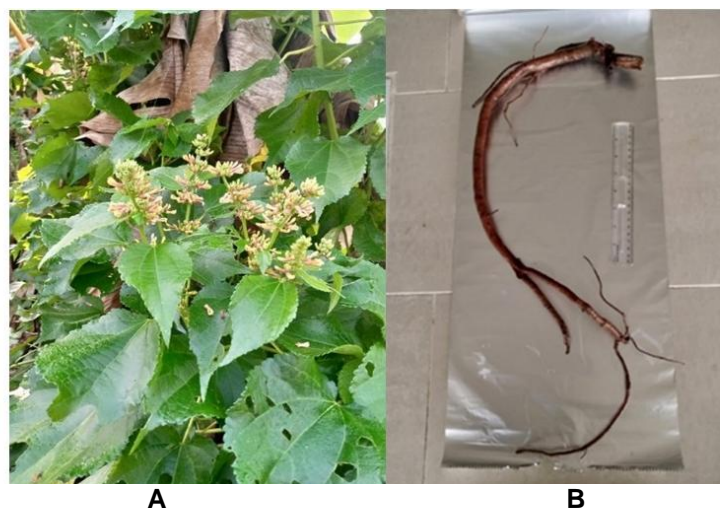


Fig. 1. Photography of Aerial part (A) and roots (B) of *Triumfetta cordifolia*

2.6 Phytochemical Screening

Phytochemical screening was carried out on the methanol/dichloromethane extract of *Triumfetta cordifolia* using standard procedures described by [11-13].

2.7 Evaluation of Analgesic Activity

2.7.1 Acetic acid test

The method used was described by Koster et al. (1959) [13]. Abdominal contractions were induced by intraperitoneal injection of acetic acid (1%, 10 ml/kg) in mice. Thirty minutes before acetic acid injection, mice were pretreated with the methanol/dichloromethane extract of *T. Cordifolia* (50, 100 and 200 mg/kg), distilled water (10 mL/kg) and paracetamol (150 mg/kg). The number of abdominal contortions per mouse was recorded for 30 minutes and this directly after the injection of acetic acid [14]. The analgesic effect was evaluated using the following formula 1 [15].

(Average of the contortions of the control group - Average of the contortions of the treated group) × 100/ Average of the contortions of the control. (1)

2.7.2 Formalin test

The formalin test method was described by Dubuisson and Dennis (1977) [16]. Formalin (1%, 20 µL) was injected into the subplantar of the right hind paw of the animals to induce pain. The paw licking time was observed for 0-5 min (early phase) and 15-30 min (late phase) after formalin administration [17]. Mice were treated with the methanol/dichloromethane extract of *T. cordifolia* (50, 100, 200 mg/kg), distilled water (10 ml/kg) or tramadol (10mg/kg); Thirty minutes before formalin injection. The percentage of inhibition (PI) of paw licking time was evaluated using equation 2:

$$(T - T')/T \times 100 \quad (2)$$

Where

T represents the mean value of the time licking of the vehicle control group for each phase and T' represents the mean value of the time licking of the assays group for each phase [16].

2.8 Evaluation of Anti-inflammatory Activity

2.8.1 *In vitro*: Bovine serum albumin denaturation test

The method used will be that of inhibition of heat-induced Bovine Serum Albumin denaturation [18]. The reaction medium consisted of 0.2 ml BSA (0.4%, w/v) prepared in phosphate-buffered-saline buffer (PBS), 2.8 ml of PBS and 2 ml of our extract solution at the concentrations 50, 100 and 200 µg/mL). As a control, we used distilled water and diclofenac (reference drug). Subsequently, the mixture was incubated at 37°C for 15 minutes and then heated to 70°C for 5 minutes in a water bath. After cooling the mixture, the absorbance is measured at 660nm and each experiment is repeated three times. The percentage of inhibition is calculated using formula 3:

Percentage of inhibition (%) = (absorbance of the test - absorbance of the negative control) × 100 / absorbance of the negative control. (3)

2.8.2 *In vivo*: carrageenan-induced rat paw edema experiment

The rats were fasted for 12 hours before the experiment. They were randomly divided into 5 groups of 5 rats each: Batch 1: negative control received a vehicle, distilled water at 10 ml/kg body weight. Batch 2: positive control received a reference drug, diclofenac at 10 mg/kg of body weight. Groups 3, 4 and 5 received extract at increasing doses of 50,100 and 200 mg/kg thirty minutes after oral gavage. Edema was induced in rats by injection into the right plantar aponeurosis of the rat of 0.1 ml of carrageenan 1%. Plethysmometric measurements were recorded before and after injection at 1/2h, 1h, 2h, 3h, 4h, 5h and 6h [19]. The percentages of inhibition (PI) were calculated using formula 4:

$$PI (\%) = ((Vt - Vo) - (Vt - Vo)) \times 100 / (Vt - Vo) \quad (4)$$

Vt = average paw volume in each group at a time t

Vo = mean volume in each group before injection

2.9 Statistical Analysis of Results

Data are expressed as an average ± SEM. The calculation of averages and percentages of inhibition was done using the Microsoft Excel 2016 spreadsheet. comparisons between

experimental and control groups were performed by one-way analysis of variance (ANOVA) followed by Turkey's post-test and two-way analysis of variance followed by Turkey's post-test using GraphPad Prism® software version 8.0.1. Differences are considered significant at the $p < 0.05$.

3. RESULTS

3.1 Phytochemical Study

Phytochemical analysis of *Triumfetta cordifolia* extract revealed the presence of: alkaloids, saponins; flavonoids, sterols, terpenes, tannins, reducing sugars and coumarins (Table 1).

3.2 Acute Toxicity

3.2.1 Mortality and lethal dose 50

Triumfetta cordifolia root extract administered at doses of 1000 mg/kg and 2000 mg/kg body weight did not produce any mortality during the

14 days of monitoring after extract administration. No signs of major toxicity or mortality were observed at any dose level after 14 days of acute toxicity testing. The lethal dose 50 (LD₅₀) has been estimated above 5000 mg/kg of body weight.

3.2.2 Behavioral changes and adverse reactions

During the first 3 hours after administration of *Triumfetta cordifolia* root extract at doses 2000 mg/kg and 5000 mg/kg; no signs of toxicity were revealed during these hours. During 14 days of observation, there were not major variation signs of toxicity in this work and no deaths were recorded (Table 2).

3.2.3 Effects of *Triumfetta cordifolia* root extract on body weight

We noticed a normal increase in the masses of all rats without significant differences between the control batch and the test batches (Fig. 2).

Table 1. Phytochemical screening of *Triumfetta cordifolia* methanol/dichloromethane root extract of *Triumfetta cordifolia*

Metabolites	Methanol/dichloromethane roots extract of <i>Triumfetta cordifolia</i>
Alkaloids	+
Saponins	+
Flavonoids	+
Sterols	+
Tannins	+
Reducing sugars	+
Coumarins	+
Terpenes	+
Anthraquinones	-
Anthocyanins	-

(+) Present (-) absent

Table 2. Clinical signs of rats in acute toxicity of *Triumfetta cordifolia* root extract

Clinical Signs	Groups		
	Distilled water	Extract 2000mg/kg	Extract 5000mg/kg
Fecal consisting	N	N	N
Aspects of the coat	N	N	N
Diarrhea	A	A	A
Vomiting	A	A	A
Respiration	N	N	N
Tremors	N	N	N
Tachycardia	N	N	N
unrest	N	N	N
Convulsions	A	A	A
Death	A	A	A

Absence (A)/ Normal (N)

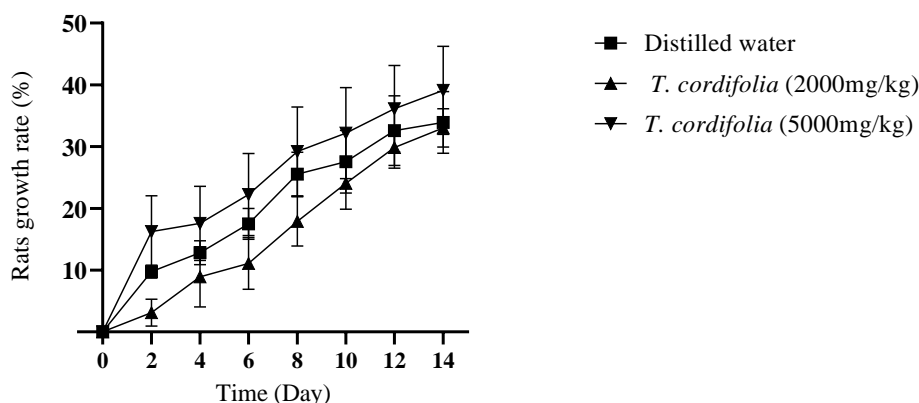


Fig. 2. Evolution of variation in rat body weight as a function of time
Each points represents the growth rate weight \pm ESM, *T. c* = *Triumfetta cordifolia* at doses of 2000 and 5000 mg/kg.

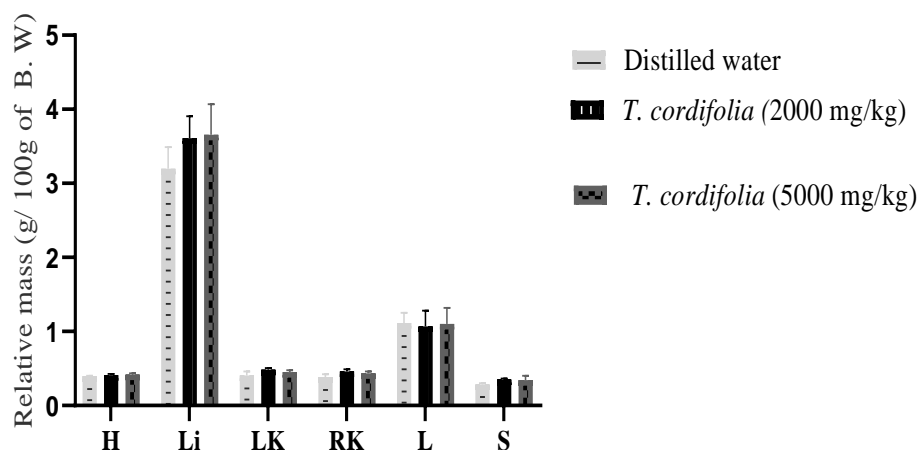


Fig. 3. Effect of *T. cordifolia* extract on relative organ mass
Each bar represents the average of relative organ weight; n=5; H= Heart, l=liver, LK=left kidney, RK=right kidney, L=lung, S=spleen

3.2.4 Effects of *Triumfetta cordifolia* root extract on organ weights

There was no significant difference in organ weights of *Triumfetta cordifolia* root extract-treated rats as compared to the control rats at the end of the acute toxicity study (Fig. 3).

4. ANALGESIC EFFECT OF THE ROOTS EXTRACT OF *Triumfetta cordifolia*

The antinociceptive activity of the methanol/dichloromethane extract was evaluated in several experimental models: the acetic acid-induced writhing and the formalin test.

4.1 Effect of the Extract on Acetic Acid-Induced Pain

The manifestation due to an intraperitoneal injection of acetic acid is characterized by abdominal writhings as shown in Fig. 4. We noticed that the plant extract significantly decrease ($P < 0.0001$) the number of abdominal writhings induced by intraperitoneal injection of acetic acid in rats. The highest inhibition was 79.45% at the dose of 200 mg/kg of body weight. Paracetamol used as a reference drug, has decreased the number of writhings (67.12%) at 50 mg/kg.

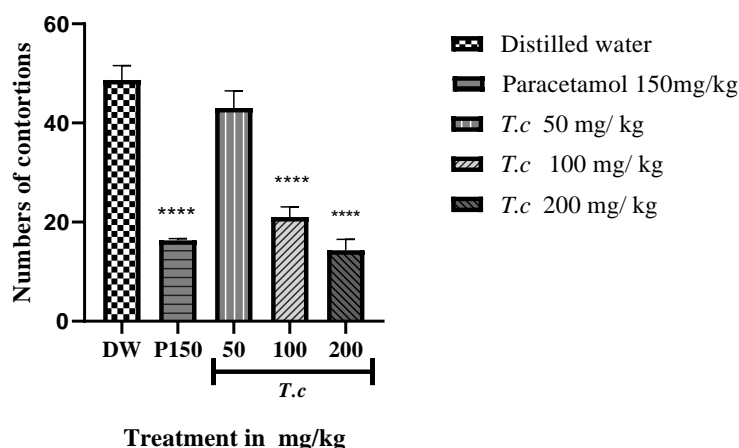


Fig. 4. Effect of extract *Triumfetta cordifolia* on the Number of abdominal contortions induced by acetic acid injection according to treatments

Each bars represents the average of abdominal contortions; $n=5$; **** $P<0.0001$ significant difference from negative control; NC = negative control, P150 = paracetamol at 150 mg/kg, T. c = *Triumfetta cordifolia* at doses of 50, 100 and 200 mg/kg.

4.2 Effect of the Extract on Formalin-Induced Pain

Subplantar injection of formalin induces biphasic pain in mice characterized by paw licking. Fig. 5 shows us the licking time of the paw in the different phases of observation. It follows from this figure that in the first phase (0-5min) the licking time decreases from 46.92 ± 3.99 seconds in animals of the negative control to $41.72\pm4.82s$, $43.69\pm6.90s$, and $30.92\pm3.76s$ respectively in animals treated with the extract at the respective

doses of 50, 100, and 200 mg/kg. The respective percentages of inhibition obtained are: 11.07%, 6.86%, 34.10% ($p<0.0001$) compared to the negative control. During the second phase, the paw licking time decreased from $97.77\pm11.30s$ to $52.35\pm11.51s$, $77.01\pm7.953s$, and $93.77\pm11.83s$ for animals treated with the extract at 50, 100 and 200 mg/kg. Furthermore, tramadol used as a reference substance inhibited pain at 35.44% ($P< 0.001$) in first phase (0-5min) and 53.04% ($P< 0.0001$) in the second phase II (15-30 min).

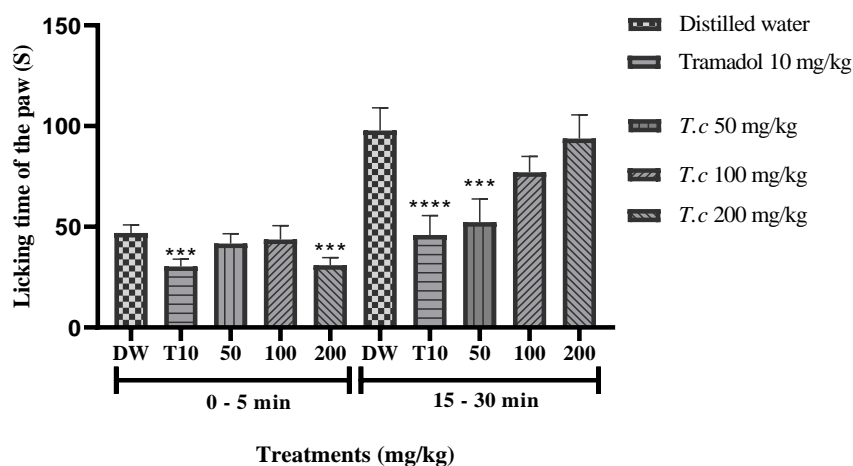


Fig. 5. Effect of *T. cordifolia* on paw licking time induced by formalin injection according to treatments

Each bar represents the average of licking time \pm SEM, $n=4$, **** $P<0.0001$ and *** $P<0.001$: significant difference from the negative control; NC = negative control, PC = positive control (tramadol 10 mg/kg), T. c = *Triumfetta cordifolia* at doses of 50, 100 and 200 mg/kg

Table 3. Variation of paw edema on carrageenan test

Treatments	Dose (mg/kg)	Variation in the volume of paw oedema (ml)						
		1/2h	1h	2h	3h	4h	5h	6h
Distilled water	10	0.28± 0.02	0.30± 0.04	0.91± 0.02	1.13 ± 0.02	1.64± 0.39	1.36 ± 0.05	1.47 ± 0.05
Diclofenac	10	0.17 ± 0.04 (41.59%)	0.12 ± 0.07 (62.48%)	0.19 ± 0.07 (78.29 %)	0.20 ± 0.07 (82.00 %)	0.18 ± 0.06 (88.58 %)	0.64 ± 0.05 (52.94 %)	0.73± 0.03 (49.82 %)
<i>T. cordifolia</i>	50	0.21 ± 0.05 (23.01%)	0.21 ± 0.04 (29.85 %)	0.55 ± 0.02 (39.28%)	0.46 ± 0.03 (59.11 %)	0.47 ± 0.02 (71.38 %)	0.81 ± 0.09 (40.07%)	0.77 ± 0.11 (47.61%)
<i>T. cordifolia</i>	100	0.12 ± 0.03 (55.75%)	0.13 ± 0.02 (55.13%)	0.46 ± 0.06 (48.9%)	0.53 ± 0.03 (52.44%)	0.79 ± 0.10 (51.59%)	0.93 ± 0.04 (31.61%)	0.95 ± 0.06 (35.20%)
<i>T. cordifolia</i>	200	0.17± 0.01 (39.82%)	0.20 ± 0.04 (32.79%)	0.58 ± 0.08 (35.44%)	0.49 ± 0.03 (56.00 %)	0.98 ± 0.03 (40.03%)	1.07 ± 0.03 (20.95 %)	1.06 ± 0.07 (28. 03%)

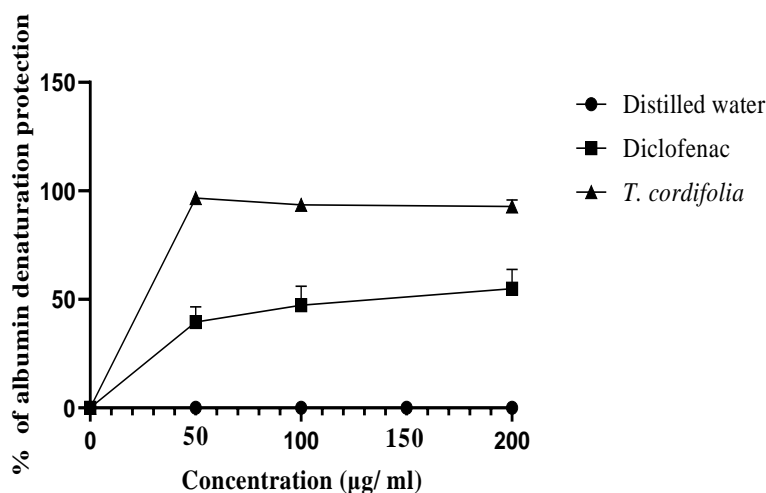


Fig. 6. Variation of the percentage of inhibition of methanol/ dichloromethane extract due to concentration. n=3

4.3 Anti-inflammatory Effect of the Root Extract of *Triumfetta cordifolia*

4.3.1 Effect of *Triumfetta cordifolia* extract on BSA denaturation

The result of the evaluation of the *In vitro* anti-inflammatory effect of the bark of *Triumfetta cordifolia* is shown in Fig. 6. It is observed that the maximum inhibition of 99.66% is obtained at the concentration of 50µg/ml. Statistical analysis shows a significant difference ($P < 0.05$) between different concentrations of extract or diclofenac compared to the negative control.

4.3.2 Effect of *Triumfetta cordifolia* Extract on Carrageenan-induced Paw Oedema

The anti-inflammatory effect of *Triumfetta cordifolia* is evaluated on carrageenan-induced plantar edema induced by carrageenan injection; indeed, in the control group, the edema induced in rats by carrageenan was maintained throughout the experiment. Treatment with the extract significantly ($P < 0.001$) reduced edema at all times. The maximum inhibition was observed at a sixth hour with a percentage of 71.38% (50 mg/kg); extract at the dose of 100 mg/kg has its maximum inhibition at the 30th minute (55.73%) and the 1st hour (55.12%) respectively while 200 mg/kg inhibited at the 3rd hour for 56%. These percentages are obtained compared to the negative control. Similarly, the reference molecule (diclofenac) showed significant ($P < 0.0001$) inhibition every hour with a maximum inhibition of 88.58% at the 4th hour (Table 3).

5. DISCUSSION

For the acute toxicity study of the methanol/dichloromethane extract of *T. cordifolia*, all animals treated at a single dose of 2000mg/kg or 5000mg/kg showed no signs of toxicity. The root extract of *T. cordifolia* did not cause any death. Suggesting that the median 50 lethal dose (LD₅₀) of the extract is higher than the limit doses administered (5000 mg/kg). This is consistent with the results obtained by Wansi et al. which showed that the LD₅₀ of *T. Pentandra* is greater than 5000 mg/kg [20].

Phytochemical screening of the methanol/dichloromethane extract of *T. cordifolia* revealed the presence of polyphenols, flavonoids, alkaloids, coumarins, saponins, reducing sugars, steroids and tri-terpenes while anthocyanins and anthocyanosides are absent. A similar result has been obtained by Sandjo et al. [21]. The phytochemicals present in the roots of the plant may be related to their pharmacological properties [22-24].

Regarding the analgesic study effects of *Triumfetta cordifolia* root extract in mice, intraperitoneal injection of acetic acid causes pain in animals characterized by abdominal contortions and abdominal stretching [25]. Indeed, acetic acid indirectly generates inflammatory pain related to stimulation of peripheral nociceptive neurons by endogenous mediators such as serotonin, histamine, bradykinin, and prostaglandins that activate the nociceptors responsible for the transmission of

pain impulses by cell trauma [26,27]. Pretreatment with the extract significantly reduced ($p < 0.0001$) contortions and maximum inhibition was achieved at a dose of 200mg/kg, for an inhibition percentage of 79.45%. The results obtained indicate the peripheral analgesic activity of the extract and suggest that it would have an inhibitory action on mediator's release or a direct inhibitory action on nerve endings involved in peripheral pain.

The acetic acid test is useful to screen substances with analgesic properties; the intraplantar injection of formalin was chosen as an additional test to elucidate whether the extract acts on peripheral or central nervous systems. The pain induced by intraplantar injection of formalin in mice is a biphasic pain characterized by licking the paw. Phase I or early phase (neurogenic pain) occurs during the first 5 minutes after injection and phase II or late (inflammatory pain) begins at the 10th minute with a maximum between the 20th and 30th minutes [28]. During the first phase, nociception is triggered by the activation of primary afferent sensory neurons (fibers C) and during the second phase, nociception is triggered by the release of inflammatory cytokines [29,30]. Administration of the methanol/dichloromethane extract of *T. cordifolia* showed significant inhibition in both phases. The highest percentages of inhibition of our extract were 34.10% ($p < 0.001$; 200 mg/kg) in the first phase and 46.45% ($p < 0.001$) 50 mg/kg) in the second. The extract could act as a central analgesic either by preventing the increase in impulse generated at the peripheral ends of the C fibers or by inhibiting the release of chemical mediators [31]. Tramadol significantly inhibited ($p < 0.0001$; $p < 0.001$) respectively both phases of formalin-induced pain.

The action of the extract on visceral pain and on the late phase at 50mg/kg of formalin-induced pain suggests that our extract may have anti-inflammatory activity. To prove this hypothesis, we performed an anti-inflammatory assay *In vitro* using bovine serum albumin denaturation protection power and *In vivo* by the carrageenan-induced paw edema test. Protein denaturation is one of the causes of inflammation. The possible mechanism of denaturation consists of the alteration of electrostatic, hydrogen, hydrophobic, and disulphide bonds that maintain the three-dimensional structure of proteins [32]. The results of the anti-inflammatory activity *In vitro* showed the highest percentage of protection of

96.66 % at 50 mg/kg which would justify that the plant could be endowed with anti-inflammatory properties.

Carrageenan-induced paw edema is an *In vivo* model commonly used in the evaluation of the anti-inflammatory properties of various compounds [33]. This is a triphasic response that involves the release of several inflammatory mediators. The first phase lasts about an hour after the injection of carrageenan is characterized by the release of histamine and serotonin, the second phase is related to the release of kinins and, the third phase is attributed to prostaglandins and leukotrienes, which lasts 3 to 5 hours [34]. These chemicals increase vascular permeability during their production, thus promoting the accumulation of fluid in the tissues that explain the edema [35]. In this study, pretreatment with the methanol/dichloromethane extract of *T. cordifolia* resulted in an effective inhibition of the volume of edema compared to the negative control. Maximum inhibition (71.38%) is achieved at a dose of 50 mg/kg 4 h after carrageenan injection. These results suggest that our extract may exert inhibitory activity on the release of pro-inflammatory mediators, including histamine, serotonin, bradykinin, prostaglandins, and leukotrienes. Diclofenac (10 mg/kg) used as the reference molecule also showed a maximum inhibition of 88.58% in the 4th hour. Non-steroidal anti-inflammatory drugs such as diclofenac are cyclooxygenase inhibitors, which lead to the inhibition of prostaglandin, prostacyclin, and thromboxane. Diclofenac can also affect the release and absorption of arachidonic acid and may also inhibit lipoxygenases [36].

Anti-inflammatory and analgesic activities can be justified by the result of phytochemical screening. Indeed, the result of phytochemical screening of the methanol/ dichloromethane extract of *T. cordifolia* reveals the presence of secondary metabolites such as alkaloids, flavonoids, triterpenes, and steroids. These results are consistent with those obtained by Sandjo et al. [21]. A study by Ngolsou et al. reveals that the proportion of total flavonoids in *T. cordifolia* represents 14% of the total amount of phenolic compounds [37]. A flavonoid: trans-tiliroside had been isolated from the leaves of *T. cordifolia* [21,38]. Sandjo et al. identified steroids: stigmaterol, β -sitosterol and triumfettosterol Id; they also isolated nine triterpenoids, including lupeol, and betulin [21]. The presence of compounds such as steroids, triterpenes and

flavonoid alkaloids could give the plant analgesic and anti-inflammatory properties. The presence of flavonoids in the studied extract could generate anti-inflammatory activity by inhibiting the production of the very active pro-inflammatory molecules: prostaglandins. This effect would be due to the reduction in arachidonic acid metabolism by inhibiting lipoxygenase, cyclooxygenase, and phospholipase A2 [38-40]. The results are in line with those obtained by Imomotimi et al. [9] in Nigeria, who isolated flavonoid compounds from the methanolic extract of *T. cordifolia* and demonstrated analgesic and anti-inflammatory activity in an animal model. These findings confirm that different parts of the *T. cordifolia* plant may be responsible for the anti-inflammatory properties.

6. CONCLUSION

The results obtained indicate that the root extract of *T. cordifolia* in methanol/dichloromethane is without acute toxicity and possesses peripheral and central analgesic properties as well as anti-inflammatory properties *In vivo* and *In vitro*. These effects could be due to the presence of phytochemicals observed in the plant. These experimental results support the traditional use of this plant in the treatment of inflammatory and painful diseases.

CONSENT

It is not applicable.

ETHICAL APPROVAL

All experiments were carried out according to the protocol approved by the Institutional Ethics Committee for Health Science of the University of Douala (protocol approval number 3165 CEI-Udo/06/2022/T)

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Raja SN, Carr DB, Cohen M, Finnerup NB, Flor H, Gibson S, Keefe FJ, Mogil JS, Ringkamp M, Sluka KA, Song XJ, Stevens B, Sullivan MD, Tutelman PR, Ushida T, Vader K. The revised IASP definition of pain: Concepts, challenges, and compromises. *Bread*. 2020;161(9):1976-1982.

2. Ji RR, Xu ZZ, Gao YJ. Emerging targets in neuroinflammation-driven chronic pain. *Nat Rev Drug Discov*. 2014; 13:533–548.
3. Varela ML, Mogildea M, Moreno I, Lopes A. Acute inflammation and metabolism. *Inflammation*. Springer Nature. 2018;41: 1115-1127.
4. Cieza A, Causey K, Kamenov K, Hanson SW, Chatterji S, Vos T. Global estimates of the need for rehabilitation based on the Global Burden of Disease study 2019: a systematic analysis for the Global Burden of Disease Study 2019. *Lancet*. 2020;396: 2006–2017.
5. Kumar T, Jain V. Antinociceptive and anti-inflammatory activities of *Bridelia retusa* methanolic fruit extract in experimental animals. *The Scientific World Journal*. 2014;2014. Article ID 890151
6. Badiaga M. Etude ethnobotanique, phytochimique et activités biologiques de *Nauclea latifolia* Smith, une plante médicinale africaine récoltée au Mali. Université Blaise Pascal - Clermont-Ferrand II. French., Ph.D. Thesis ; 2011.
7. *Triumfetta cordifolia* A.Rich. - Prota4U, www.protau.org, [accessed on 23/11/2021] on <https://www.prota4u.org/database/protav8.asp?fr=1&g=pe&p=Triumfetta+cordifolia+A.Rich>
8. Dohbit JS, Meka E, Tochie JN, Ze MMK, Essiben F, Agbor VN, Nkeck JR, Foumane P. Exploring the effects of peri-partum ingestion of traditional medicine on maternal and foetal outcomes: A prospective cohort study. *BMC Res Notes*; 2019. Available:<https://doi.org/10.1186/s13104-019-4199-y>
9. Ajoko IT, Amos-Tautua BM, Bamgbade EO. HPLC Analysis and Anti-Inflammatory Effect of Methanol Extract of the Leaves of *Triumfetta cordifolia* A. Rich. (*Malvaceae*) Available in Bayelsa State, Nigeria. *Sch Int J Chem Mater Sci*. 2023;6(6):115-25.
10. Organisation for Economic Co-operation and Development (OECD), Test No. 425: Acute Oral Toxicity: Up-and-Down Procedure, OECD Guidelines for the Testing of Chemicals, Section 4, Éditions OCDE, Paris; 2022. DOI:10.1787/9789264071049-en.
11. Trease GE, Evans WC. *Pharmacognosy*. 11th Edition, Bailliere Tindall, London. 1989;45-50.

12. Odebiyi OO, Sofowora EA. Phytochemical Screening of Nigerian. Medicinal Plants Part II: Iloydia. 1978;41:1-25.
13. Sofowora AA. Medicinal plants and traditional medicine in West Africa, 3rd edn. John Wiley and Sons Ltd. New York. 2008;200-203.
14. Koster R, Anderson M, De Beer EJ. Acetic Acid for Analgesic Screening. Federation Proceedings. 1959;18:412-417.
15. Sanogo R, Maïga A, Diallo D. Activités analgésique et anti-inflammatoire des extraits de *Maytenus senegalensis*, *Stereospermum kunthianum* et *Tricrilia emetica* utilisées dans le traitement traditionnel des dysménorrhées au Mali. Pharm. Méd. Trad. Afr. 2006;14:123-136.
16. Dubuisson D, Dennis SG. The formalin test: A quantitative study of the analgesic effects of morphine, meperidine, and brain stem stimulation in rats and cats: Pain. 1977;4:161-174.
17. Boukanika M, Fita W, Kaka Z. Evaluation de l'activité anti-inflammatoire et antalgique de l'extrait éthanolique de la propolis de Jijel. French; 2018, MSc Thesis.
18. Haioun A, Hamoudi FZ, Ihoual S. Activité antioxydante et anti-inflammatoire de la plante médicinale Algérienne *Anethium graveolens* et leur effet cardioprotectrice contre la toxicité de la Doxorubicine. Constantine. Université Frères Mentouri Constantine. French, MSc Thesis; 2015.
19. Winter CA, Risley EA, Nuss GW. Carrageenin-induced edema in hind paw of the rat as an assay for anti-inflammatory drugs. Proceedings of the Society for Experimental Biology and Medicine. 1962;111(3):544-7.
20. Wansi SL, Kamani SLP, Miaffo D, Simo YT, Fokam Z, Nangué C, Kamanyi, A. Acute and subchronic oral toxicity assessment of leaves aqueous extract of *Triumfetta pentandra* (*Tiliaceae*) on mice and rats, World J Pharm Sci. 2016;4(1):14-22.
21. Sandjo L, Tchoukoua A, Ntede H, Yemloul M, Perspicace E, Keumedjio F, Couty F, Kirsch G, Tchaleu Ngadjui B. New Nortriterpenoid and Ceramides From Stems and Leaves of Cultivated *Triumfetta cordifolia* A Rich (*Tiliaceae*). J Am Oil Chem Soc. 2010;11.
22. Sandjo L, Hannewald P, Yemloul M, Kirsch G, Tchaleu Ngadjui B. Triumfettamide and Triumfettoside Ic, Two ceramides and other secondary metabolites from the stems of Wild *Triumfetta cordifolia* A. Rich. (*Tiliaceae*). HCA. 2008;91(7):1326-1335.
23. Ajoko I, Amos B, Songca P. Ethnomedicinal and economical profile of *Triumfetta cordifolia*: A mini-review; Journal of Medicinal Plants Studies. 2020;8(5):208-212.
24. Orodeh V, Aderibigbe A, Benneth B. Evaluation of the psychopharmacological properties and neural mechanisms of action of the ethanol extract of leaves of *Triumfetta cordifolia* in mice. J Pharm Bio. 2019;16(1):76.
25. Lee YY, Saba E, Irfan M, Kim M, Chan JY, Jeon BS, Choi SK. The anti-inflammatory and anti-nociceptive effects of Korean black ginseng. Journal of Physica Medica. 2018;54:169-181.
26. Dongmo A, Nguenefack T, Lacaille-Dubois M. Antinociceptive and anti-inflammatory activities of *Acacia pennata* wild (*Mimosaceae*). Journal of Ethnopharmacology. 2005;98,201-206.
27. Frederico A, Higor F, Elson A. Evaluation of the antinociceptive and anti-inflammatory effects of the acetone extract from *Anacardium occidentale*. Journal of Pharmascience. 2009;45:437-442.
28. Coderre TJ, Vaccarino AL, Melzack R. Central nervous system plasticity in the tonic pain response to subcutaneous formalin injection. Brain Research, 1990;535:155-158.
29. Nozaki C, Vergnano AM, Filliol D, Ouagazzal AM, Le Goff A, Carvalho S, et al. Zinc soulage la douleur par liaison de haute affinité à la sous-unité NR2A du récepteur NMDA. Nat Neurosci. 2011;14(8):1017-1022.
30. Holzer P. Capsaïcine: cibles cellulaires, mécanismes d'action et sélectivité pour les neurones sensoriels minces. Pharmacol Rev. 1991;43(2):143-201.
31. Levet E. Les anti-inflammatoires non stéroïdiens : Facteurs de risque d'aggravation des infections bactériennes, connaissance par le pharmacien d'officine de ce risque potentiel. Faculté de Médecine de Strasbourg, French. Ph.D. Thesis; 2006.
32. Barros L, Falcão S, Baptista P, Freire C, Vilas-Boas M, Ferreira ICFR. Antioxidant activity of *Agaricus* sp. mushrooms by chemical, biochemical and electrochemical assays. Food Chem. 2008;111:61-66.

33. Just MJ, Recio MC, Giner RM, Cuellar MJ, Manez S, Bilia AR. Activité anti-inflammatoire de saponines de lupane inhabituelles de *Bupleurum fruticosens*. *Planta Medica*. 1998;64:404-407.
34. Di Rosa M, Giroud JP, Willoughby DA. Study of the mediators of the acute inflammatory response induced in rats in different sites by carrageenin and turpentine. *Journal of Pathology*. 1971;104:15-29.
35. Umukoro S, Ashorobi R. Evaluation of anti-inflammatory and membrane stabilizing property of aqueous leaf extract of *Momordica charantia* in rats. *African Journal of Biomedical research*. 2009;9:119-124.
36. Gan TJ. Diclofenac: an update on its mechanism of action and safety profile. *Curr Med Res Opin*. 2010;26:1715-1731.
37. Foumane Maniepi JSN, Soppo Lobe V, Nnanga Nga, Metogo Ntsama JA, Mbenga Mekoulou FC, Ngolsou F, Betoté Diboué P, Obono P, Nyangono Ndongo M, Ze Minkande J. 2022. Phytochemical analysis of aqueous extracts of *Sida acuta* and *Triumfetta cordifolia*, two plants used to facilitate childbirth in traditional medicine in Cameroun. *Health Sci. Dis*. 2022;23(2 Suppl 1):14-18.
38. Ogundajo A, Ndukwe N, Owolabi M, Setzer W. Chemical compositions and antifungal activities of essential oil from *Triumfetta cordifolia*. 2021;57:485-486.
39. Manthey JA. Biological properties of flavonoids pertaining to inflammation. *Microcirculation*. 2000, 7(S1).
40. Bozorgi M, Memariani Z, Mobli M, Salehi S M, ShamsArdekani M R, & Rahimi R. (2013). Five *Pistacia* species (*P. vera*, *P. atlantica*, *P. terebinthus*, *P. khinjuk*, and *P. lentiscus*): a review of their traditional uses, phytochemistry, and pharmacology. *The Scientific World Journal*. 2013;15: 219815.

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