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Analgesic effects of methanolic extracts of the leaf or root of *Moringa oleifera* on complete Freund's adjuvant-induced arthritis in rats

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Objective: *Moringa oleifera* (family Moringaceae) has been widely used in African folk medicine, and researchers have recently revealed its anti-inflammatory effects in human. This study aimed to evaluate the analgesic properties of methanolic extracts of *M. oleifera* in complete Freund's adjuvant (CFA)-induced arthritis in rats.
Methods: Adult male Wistar rats, weighing 200 to 220 g, were used in this study. Adjuvant arthritis was induced on day 0 by a single subcutaneous injection of CFA. The prepared extracts from both the root and leaf (200, 300 and 400 mg/kg) of *M. oleifera* were administered intraperitonealy to rats in the treatment groups 0, 3 and 6 d after CFA injection and indomethacin (5 mg/kg) was used as a positive control drug. Thermal hyperalgesia and mechanical allodynia were evaluated for the analgesic effect 0, 3 and 6 d after CFA injection. Combined methanolic root and leaf extracts of *M. oleifera* (200 mg/kg) were also tested for the analgesic effect.
Results: The potency of the root or leaf extracts of *M. oleifera* (300 and 400 mg/kg) was similar to that of indomethacin, resulted in significant reductions in both thermal hyperalgesia and mechanical allodynia in rats with CFA-induced arthritis compared with the control group after 3 and 6 d, respectively ($P<0.01$ or $P<0.05$). Combined root and leaf extracts (200 mg/kg) of *M. oleifera* resulted in a significant reduction in thermal hyperalgesia compared with the control group after 3 and 6 d, respectively ($P<0.01$). Prophylactic injections of combined root and leaf extracts of *M. oleifera* (200 mg/kg) resulted in a significant reduction in thermal hyperalgesia compared with the control group, the root extracts group, and the leaf extracts group after 3 and 6 d, respectively ($P<0.01$).
Conclusion: The methanolic extracts of the root or leaf of *M. oleifera* are effective in the reduction of pain induced by CFA in rats. A comparison of single and combination therapies of root and leaf extracts also showed a synergistic effect on pain reduction.

Keywords: *Moringa oleifera*; plant extracts; analgesics; arthritis, experimental; hyperalgesia; Freund's adjuvant; rats

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Moringa oleifera (Moringaceae family) is a bush of the African savannah that is used in folk medicine for the treatment of rheumatic and articular pain. The whole plant is believed to possess medicinal properties. It is used to treat ascites, rheumatism, venomous bites and pneumonia[1]. *M. oleifera* is a small- to medium-sized tree that is found in most western areas of Bengal. Various parts of this plant have been used in tribal medicine. *M. oleifera* is commonly used in the treatment of rheumatic swellings in traditional medicine[2]. Flowers and young leaves are also consumed for nourishment. The methanolic extracts of the *M. oleifera* root can act as a central nervous system depressant[3], and the aqueous root extracts have been shown to possess some anti-infertility properties in rats[4, 5]. A paste of the leaves is also used to treat dermal wounds. Moreover, the leaves contain a large amount of proteins and are a rich source of essential amino acids, such as methionine, cysteine, tryptophan and lysine. The leaves are also considered a potential source of natural antioxidants. Both methanolic and ethanol extractions from the leaves have been shown to be the best source of antioxidant compounds[6]. *M. oleifera* not only produces analgesia in mice but also potentiates the analgesic effects of morphine and pethidine[2]. The macerated root of *M. oleifera* is used by herbalists in West Africa to treat inflammatory conditions. The methanolic extract of the root possesses anti-inflammatory properties, which is effective in the treatment of both acute and chronic inflammation[3]. The composition and anti-inflammatory effects of the *M. oleifera* root have been studied, but the analgesic properties have not yet been elucidated[6]. In recent decades, the effects of extracts from the leaves, seeds and roots of *M. oleifera* on dermal wounds[7] and in pain treatment[8] have been extensively studied. Rheumatoid arthritis (RA), which is characterized by chronic inflammatory changes, cartilage destruction, joint deformity and disability[9], is one of the most common rheumatic conditions. The pain of RA is more unbearable than any other form of arthritis[10]. This study investigated the possible analgesic properties of *M. oleifera* root or leaf extracts as well as a combination of the two in male rats with complete Freund's adjuvant (CFA)-induced arthritis.

1 Materials and methods

1.1 Plant materials

1.1.1 Extract preparation African generation of *M. oleifera* was collected between June and July of 2009. The specimens were identified in the Central Herbarium of Iran (Central Herbarium of Medicinal Plants, Academic Center for Education, Culture and Research, Tehran, Iran). The voucher specimen was deposited there with No. 66. The plant materials were cleaned and shade dried prior to extraction. Analytical grade solvents were used for extraction. Quercetin was used as standard flavonoid (Sigma-Aldrich, St. Louis, Missouri, USA); solvents for chromatographic analyses were obtained from Panreac Química S. A. U., Spain; minor chemicals, such as acetic acid and anhydrous sodium sulfate, were obtained from Merck & Co., Inc. The aerial portion and roots (200 g) of the plant were subjected to maceration with methanol (99.9%) for 72 h, and the methanolic extracts were then filtered. The extracts were then evaporated in vacuum at the temperature of about 40 ℃. The yields for the methanolic extracts were determined, and the dried extracts were kept at 4 ℃ until use. By using Tween 80 as solubilizing agent, the dried extracts were dissolved in sterile water containing 0.9% (w/v) sodium chloride and passed through a weighed paper filter.

1.1.2 Phytochemical analyses Standard phytochemical screening tests[10] were used to screen the extracts. The plants were qualitatively analyzed to detect saponins, alkaloids and terpenoides. For quantization of flavonoids, the following high-performance liquid chromatography (HPLC) instrument was used: KNAUER ChromGate V3.1.7 software, pump K-1001, solvent organizer K-1500 (KNAUER, Germany); ODS C18 column (30 cm) and L1 (spherical, d=5 μm). Chromatography was performed at 30 ℃ with a flow rate of 1.5 mL/min, and the mobile phase was methanol (77%) and water-phosphoric acid (1 ∶ 200) (23%). The ultraviolet detector was set at 225 nm. Extracts were prepared with a minor change to the previously described method[10]. About 1.0 g of the plant, finely pulverized and accurately weighed, was transferred to a 250 mL flask fitted with a reflux condenser, and 78 mL of extraction solvent (alcohol, water, and hydrochloric acid (50 ∶ 20 ∶ 8, v/v/v)) was then added, and the solution was refluxed in a hot water bath for about 135 min. The solution was cooled to room temperature and decanted into a 100 mL volumetric flask, and 20 mL of methanol was then added to the 250 mL flask, and the solution was sonicated for 30 min, filtered and collected in a 100 mL volumetric flask. The residue on the filter was washed with methanol, and the flow-through was collected in the same 100 mL volumetric flask, diluted and mixed. A total of 20 μL of this solution was injected for HPLC analysis. Prior to analysis, a calibration curve was prepared with 0.01, 0.02, 0.05, 0.10 and 0.20 mg/mL concentrations of quercetin as the standard. Flavonoid concentrations were calculated according to an established method, and the data were presented as quercetin percentage (w/w) of plant material.

1.2 Laboratory animals Adult male Wistar rats, weighing 200 to 220 g, were used in this study. The rats were housed in individual cages with free access to food and water. They were kept in a

temperature-controlled room at (22.0±0.5) ℃ with a 12/12 h light/dark cycle (lights on from 06:00 to 18:00). The humidity of the room was kept between 60% and 62%. The study protocol was approved by the local ethics committee for the use of animals in research, and we followed the guidelines of ethical standards for the investigation of experimental pain in animals[8].

1.3 Experimental methods

1.3.1 Induction of adjuvant arthritis Adjuvant arthritis was induced on day 0 by a single subcutaneous injection into the right hindpaw of 100 μL of heat-killed *Mycobacterium tuberculosis* suspended in sterile mineral oil (10 mg/mL CFA, Sigma Chemical Co., St Louis, Missouri, USA). The right hindpaws of sham rats were injected with sterile mineral oil only (100 μL)[9]. Hindpaw unilateral edema (acute phase) was established within the first hour after CFA injection, and it was quantified during the first week[11].

1.3.2 Assessment of thermal hyperalgesia Thermal hyperalgesia was evaluated by using the previously described radiant heat method. Rats were placed in plexiglas boxes for 10 to 15 min prior to testing to habituate to the test environment. Paw withdrawal latency (PWL) in response to radiant heat was measured with a plantar test apparatus (Ugo Basile, Italy). The heat source was positioned under the plantar surface of the affected hindpaw and activated. A digital timer connected to the heat source automatically recorded the PWL to a tenth of one second. If the rat did not withdraw its paw from the stimulus after 20 s, the test was terminated, and the rat was assigned with this cut-off value. Each rat underwent three trials per hindpaw at intervals of 5 to 10 min. The mean latency of the withdrawal responses for each paw was calculated. The value for the right (CFA-injected) paw was then subtracted from the value for the left paw, and the result was considered as a measure of hyperalgesia in the injured paw[12].

1.3.3 Mechanical allodynia To evaluate the contribution of low-threshold fibers to nociceptive behavior, we studied the effects of stimulation with weak von Frey filaments with bending forces ranging from less than 2 to 60 g (Stolting Inc., Wood Dale, Illinois, USA). This stimulus is considered innocuous because it normally elicits activity in low-threshold mechanoreceptors. Rats were placed on a mesh (0.8 cm×0.8 cm) floor, covered with an inverted transparent plastic box (20 cm×20 cm×18 cm) and allowed to adapt for approximately 15 min or until exploratory behavior ceased. The central region of the plantar surface of the hindpaw was stimulated with a series of von Frey filaments in ascending order of force. The paws were stimulated three times consecutively by pushing up on the hindpaw until the rat either withdrew its paw or the fiber bowed. Lifting of the paw due to normal locomotor behavior was ignored. The withdrawal threshold represented the smallest filament size that evoked at least two withdrawal responses during three consecutive applications of the same filament. Each filament was applied for approximately 1 s, and the inter-stimulus interval was approximately 5 s[13].

1.3.4 Experimental procedure To determine the effects of *M. oleifera* root or leaf extracts on CFA-induced pain, a series of experiments were performed on rats, which were divided into various experimental groups ($n = 6$ per group). Treatments with *M. oleifera* root or leaf extracts were administered 0, 3 and 6 d after CFA injection. Thermal hyperalgesia and mechanical allodynia were measured 0, 3 and 6 d after CFA injection. In the next part of the study, rats received combined methanolic root and leaf extracts 0, 3 and 6 d after CFA injection. Thermal hyperalgesia and mechanical allodynia were assessed 30 min before CFA injection and 3 and 6 d after administration of *M. oleifera* extracts. Carboxy methyl cellulose (CMC) was used as a vehicle for dilution of the extracts and the drug. Indomethacin (5 mg/kg), a standard analgesic agent, was used as a positive control.

1.4 Statistical analysis Data were presented as $\overline{x} \pm s_{\overline{x}}$. One way analysis of variance (ANOVA) followed by post hoc Tukey's multiple comparison test (Statistica 6.0), and unpaired student t-test were used to determine significant differences in thermal and mechanical pain thresholds within and between groups where appropriate. Statistical significance was accepted at $P<0.05$.

2 Results

2.1 The yields of extracts For the aerial parts of the plant, the yields for methanolic and defatted extracts were calculated to be 16.2% (w/w) and 10.3% (w/w), respectively. For the roots, the methanolic and defatted yields were 11.7% (w/w) and 6.4% (w/w), respectively.

2.2 Phytochemical analyses results Both the aerial parts and the roots contained saponins and were rich in terpenoids. However, alkaloids were absent. The calibration curve showed good linearity with a regression value of 0.995 1. The total flavonoids content as a percentage of quercetin content was 0.65% (w/w).

2.3 Effects of *M. oleifera* leaf extracts Treatment with *M. oleifera* leaf extracts (300 and 400 mg/kg) resulted in significant reductions in both thermal hyperalgesia and mechanical allodynia after 3 and 6 d in rats with CFA-induced arthritis compared with the control group ($P<0.01$ or $P<0.05$). Effective doses of methanolic leaf extracts (300 and 400 mg/kg) significantly reduced hyperalgesia and mechanical allodynia on day 6 compared with day 3 in CFA-injected rats ($P<0.05$). There were no significant differences in thermal hyperalgesia and mechanical allodynia in rats treated with 200 mg/kg

of *M. oleifera* leaf extracts compared with the control group. Thermal hyperalgesia and mechanical allodynia were significantly reduced by treatment with 5 mg/kg of indomethacin (5 mg/kg) compared with the control group ($P<0.05$ or $P<0.01$). There were no significant differences between rats treated with effective doses of the leaf extracts (300 and 400 mg/kg) and rats treated with indomethacin (5 mg/kg) (Table 1).

2.4 Effects of *M. oleifera* root extracts Compared with the control group, rats with CFA-induced arthritis that were treated with either 300 mg/kg or 400 mg/kg of *M. oleifera* root extracts showed a significant reduction in thermal hyperalgesia after 3 and 6 d treatment ($P<0.01$). Thermal hyperalgesia significantly reduced at day 6 compared with day 3 in 300 and 400 mg/kg *M. oleifera* root extracts-treated groups. However, no significant differences in mechanical allodynia were observed, and 200 mg/kg treatment had no effect on either variable. Indomethacin (5 mg/kg) treatment also significantly reduced thermal hyperalgesia ($P<0.01$) at day 3 and day 6 after CFA injection. There were no significant differences in thermal hyperalgesia and mechanical pain thresholds between rats treated with effective doses of root extracts (300 and 400 mg/kg) and rats treated with indomethacin (5 mg/kg) (Table 2).

Table 1 Effects of *Moringa oleifera* leaf extracts on CFA-induced thermal hyperalgesia and mechanical allodynia

($\bar{x}\pm s_{\bar{x}}$)

Group	*n*	Mean value of withdrawal latencies between right and left hindpaws (second)	Mean value of threshold (g)
Control			
0 d of treament	6	0.17±0.05	60.00±1.24
3 d after treament	6	−6.38±0.25	15.14±1.32
6 d after treament	6	−5.05±0.35	12.14±2.08
Methanolic extracts (200 mg/kg)			
0 d of treament	6	0.24±0.08	60.00±1.85
3 d after treament	6	−6.43±0.35	15.29±2.05
6 d after treament	6	−4.90±0.44	15.14±1.55
Methanolic extracts (300 mg/kg)			
0 d of treament	6	0.18±0.05	60.00±1.58
3 d after treament	6	−4.33±0.31**	29.15±1.55**
6 d after treament	6	−3.90±0.09△▲	20.00±1.55△▲
Methanolic extracts (400 mg/kg)			
0 d of treament	6	0.25±0.1	60.00±2.11
3 d after treament	6	−4.50±0.23**	30.25±1.43**
6 d after treament	6	−3.45±0.15△□	22.00±1.55△□
Indomethacin (5 mg/kg)			
0 d of treament	6	0.15±0.08	60.00±2.14
3 d after treament	6	−4.85±0.30**	22.94±1.13*
6 d after treament	6	−3.10±0.35△△	19.65±1.51△

* $P<0.05$, ** $P<0.01$, *vs* control group 3 d after treatment; △ $P<0.05$, △△ $P<0.01$, *vs* control group 6 d after treatment; ▲ $P<0.05$, *vs Moringa oleifera* leaf extracts (300 mg/kg) 3 d after treatment; □ $P<0.05$, *vs Moringa oleifera* leaf extracts (400 mg/kg) 3 d after treatment. CFA: complete Freund's adjuvant.

Table 2 Effects of *Moringa oleifera* root extracts on CFA-induced thermal hyperalgesia and mechanical allodynia

($\bar{x}\pm s_{\bar{x}}$)

Group	*n*	Mean value of withdrawal latencies between right and left hindpaws (second)	Mean value of threshold (g)
Control			
0 d of treament	6	0.17±0.05	60.00±2.41
3 d after treament	6	−6.25±0.42	23.35±1.42
6 d after treament	6	−5.05±0.54	20.50±1.44
Methanolic extracts (200 mg/kg)			
0 d of treament	6	0.09±0.02	60.00±2.32
3 d after treament	6	−5.80±0.21	26.00±1.55
6 d after treament	6	−4.80±0.38	23.45±1.65
Methanolic extracts (300 mg/kg)			
0 d of treament	6	0.12±0.03	60.00±2.88
3 d after treament	6	−2.34±0.25**	22.43±1.31
6 d after treament	6	−1.40±1.09△△▲▲	22.45±1.39
Methanolic extracts (400 mg/kg)			
0 d of treament	6	0.20±0.05	60.00±2.11
3 d after treament	6	−2.66±0.56**	25.54±1.55
6 d after treament	6	−1.20±0.25△△□□	26.55±1.11
Indomethacin (5 mg/kg)			
0 d of treament	6	0.15±0.04	60.00±2.14
3 d after treament	6	−2.95±0.30**	28.65±1.30*
6 d after treament	6	−1.54±0.51△△■■	25.50±1.51△

* $P<0.05$, ** $P<0.01$, *vs* control group 3 d after treatment; △ $P<0.05$, △△ $P<0.01$, *vs* control group 6 d after treatment; ▲▲ $P<0.01$, *vs Moringa oleifera* root extracts (300 mg/kg) 3 d after treatment; □□ $P<0.01$, *vs Moringa oleifera* root extracts (400 mg/kg) 3 d after treatment; ■■ $P<0.01$, *vs* indomethacin (5 mg/kg) 3 d after treatment. CFA: complete Freund's adjuvant.

2.5 Effects of combined *M. oleifera* leaf and root extracts Treatment with combined *M. oleifera* leaf and root extracts (200 mg/kg) resulted in a dramatic decrease in thermal hyperalgesia ($P<0.01$) on day 3 and day 6 in rats with CFA-induced arthritis. However, there were no significant effects on mechanical allodynia compared with the control group. There were no significant differences in thermal hyperalgesia and mechanical allodynia between the group which administered combined *M. oleifera* leaf and root extracts (200 mg/kg) and indomethacin-treated group at different days of the study (5 mg/kg) (Table 3).

2.6 Prophylactic effects of combined *M. oleifera* leaf and root extracts Prophylactic administration of combined *M. oleifera* leaf and root extracts (200 mg/kg) resulted in a dramatic decrease in thermal hyperalgesia on day 3 and day 6 in rats with CFA-induced arthritis in comparison with the control group, the root extracts group, and the leaf extracts group, respectively ($P<0.01$). Combined extracts-treated group showed no significant difference in thermal hyperalgesia between day 3 and day 6. There were no significant differences in mechanical allodynia between the different experimental groups. There was no significant difference in mechanical allodynia between the group treated with combined *M. oleifera* leaf and root extracts (200 mg/kg) and the group treated with indomethacin (5 mg/kg) (Table 4).

Table 3 Effects of combined *Moringa oleifera* leaf and root extracts on CFA-induced thermal hyperalgesia and mechanical allodynia

($\bar{x}\pm s_{\bar{x}}$)

Group	n	Mean value of withdrawal latencies between right and left hindpaws (second)	Mean value of threshold (g)
Control			
0 d of treament	6	0.17±0.06	60.00±1.24
3 d after treament	6	−6.38±0.25	17.00±1.45
6 d after treament	6	−5.05±0.35	21.84±2.11
Methanolic leaf extracts (200 mg/kg)			
0 d of treament	6	0.24±0.11	60.00±1.85
3 d after treament	6	−6.43±0.35	17.29±1.15
6 d after treament	6	−4.90±0.44	23.14±1.45
Methanolic root extracts (200 mg/kg)			
0 d of treament	6	0.09±0.02	60.00±2.32
3 d after treament	6	−5.80±0.21	17.05±1.55
6 d after treament	6	−4.80±0.38	23.45±1.65
Combined methanolic extracts (200 mg/kg)			
0 d of treament	6	0.41 ± 0.1	60.00±2.11
3 d after treament	6	−2.62 ± 0.55**	19.25±1.45
6 d after treament	6	−2.91 ± 0.45△△	24.15±1.35
Indomethacin (5 mg/kg)			
0 d of treament	6	0.52±0.14	60.00±2.14
3 d after treament	6	−3.11±0.30**	21.54±1.24*
6 d after treament	6	−3.24±0.51△△	25.15±1.51△

* $P<0.05$, ** $P<0.01$, *vs* control group 3 d after treatment; △ $P<0.05$, △△ $P<0.01$, *vs* control group 6 d after treatment. CFA: complete Freund's adjuvant.

Table 4 Prophylactic effects of combined *Moringa oleifera* leaf and root extracts on CFA-induced thermal hyperalgesia and mechanical allodynia

($\bar{x}\pm s_{\bar{x}}$)

Group	n	Mean values of withdrawal latencies between right and left hindpaws (second)	Mean values of threshold (g)
Control			
0 d of treament	6	0.17±0.08	60.00±1.25
3 d after treament	6	−6.01±0.35	21.00±1.34
6 d after treament	6	−5.20±0.35	23.44±1.41
Methanolic leaf extracts (200 mg/kg)			
0 d of treament	6	0.24±0.09	60.00±1.65
3 d after treament	6	−6.34±0.35	23.25±1.32
6 d after treament	6	−4.54±0.44	23.90±1.35
Methanolic root extracts (200 mg/kg)			
0 d of treament	6	0.29±0.10	60.00±1.65
3 d after treament	6	−5.85±0.21	22.85±1.45
6 d after treament	6	−4.65±0.38	24.47±1.65
Combined methanolic extracts (200 mg/kg)			
0 d of treament	6	0.32±0.12	60.00±2.12
3 d after treament	6	−1.55±0.31**☆☆★★	23.05±1.41
6 d after treament	6	−1.00±0.19△△††‡‡	25.95±1.55
Indomethacin (5 mg/kg)			
0 d of treament	6	0.62±0.14	60.00±2.14
3 d after treament	6	−1.31±0.30**	25.56±1.34*
6 d after treament	6	−1.54±0.51△△	27.85±1.51△

* $P<0.05$, ** $P<0.01$, *vs* control group 3 d after treatment; △ $P<0.05$, △△ $P<0.01$, *vs* control group 6 d after treatment; ☆☆ $P<0.01$, *vs Moringa oleifera* leaf extracts (200 mg/kg) 3 d after treatment; ★★ $P<0.01$, *vs Moringa oleifera* root extracts (200 mg/kg) 3 d after treatment; †† $P<0.01$, *vs Moringa oleifera* leaf extracts (200 mg/kg) 6 d after treatment; ‡‡ $P<0.01$, *vs Moringa oleifera* root extracts (200 mg/kg) 6 d after treatment. CFA: complete Freund's adjuvant.

3 Discussion

As the most important pharmacological model of RA, rat adjuvant arthritis mimics the arthritis observed in humans. This rat model was used to test the classic non-steroidal anti-inflammatory drugs (NSAIDs)[14]. CFA injection into the paws of the rats provokes local inflammation and pain. Treatment with methanolic extracts from the leaves of *M. oleifera* resulted in a significant decrease in thermal hyperalgesia and mechanical allodynia on day 3 and day 6 after CFA injection. Treatment with methanolic extracts from the roots of *M. oleifera* resulted in a significant decrease in thermal hyperalgesia but had no significant effect on mechanical allodynia at 300 and 400 mg/kg either on day 3 and day 6 after CFA injection. These effects were comparable with the effects of 5 mg/kg of indomethacin. Gupta *et al*[2] studied the analgesic effects of the *M. oleifera* root at doses ranging from 350 to 700 mg/kg using the hot plate method. They have shown that the root of *M. oleifera* not only produced analgesia in mice but also potentiated the analgesic actions of morphine and pethidine. Ezeamuzie *et al*[3] showed that the *M. oleifera* root had anti-inflammatory effects on paw edema after 6 d in the rat air pouch inflammatory model. The phytochemical screening of the leave and root extracts of *M. oleifera* indicated the presence of various classes of chemicals, such as terpenoids, saponin glycosides and flavonoids. Flavonoids, such as quercetins, are known to be effective in reducing inflammatory symptoms. These flavonoids possess potent inhibitory effects on various enzymes, such as protein kinase C, phospholipase A2 and phosphodiesterase[15]. The aurantiamide acetate isolated from the root of *M. oleifera* has been shown to significantly inhibit inflammatory arthritis and analgesic activities during the hot plate test[16]. The alcoholic extracts of *M. oleifera* seeds have been shown to have analgesic activities comparable to those of aspirin at 25 mg/kg[17]. Cáceres *et al*[18] identified anti-inflammatory properties of 1 000 mg/kg of the root extracts of *M. oleifera* in rodents with carrageenan-induced edema. The leaves of *M. oleifera*, especially the methanolic and ethanolic extracts, are good sources of natural antioxidant compounds[19]. With respect to the different compounds in the leaves, roots and other parts of *M. oleifera* that contain different substances capable of reducing inflammation and pain, we examined a combination of the extracts from the leaves and roots (200 mg/kg). Treatment with the combined extracts resulted in a significant reduction in thermal hyperalgesia but had no significant effect on mechanical allodynia in comparison with 5 mg/kg of indomethacin. In conclusion, the methanolic extracts of *M. oleifera* root and leaf seem to be effective in reducing pain in rats with CFA-induced arthritis. A comparison of the effects of single and combination therapy with root and leaf extracts showed the synergistic activity of both in the reduction of pain. This may further suggest that, single or combination of root and leaf extracts of *M. oleifera* along with other analgesic drugs can be useful in alleviation of inflammatory pain.

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辣木叶或根的甲醇提取物对弗氏佐剂致关节炎大鼠模型的止痛作用

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目的：辣木(*Moringa oleifera*)是非洲民间医学中一种常用的药用植物，近期已有临床研究揭示了其抗炎功效。本实验研究辣木叶及根的甲醇提取物对弗氏佐剂致关节炎模型大鼠的止痛作用。
方法：使用健康雄性成年 Wistar 大鼠(体质量 200～220 g)，皮下注射弗氏佐剂建立实验性关节炎模型。造模当天及造模后第 3 天和第 6 天，治疗组大鼠分别腹腔内注射辣木根或叶的甲醇提取物(200、300 或 400 mg/kg)，使用消炎痛(5 mg/kg)作为阳性对照药。每次用药后评估各组大鼠的温度痛觉过敏程度及机械性触诱发痛程度。实验用同样方法检测了辣木根和叶的甲醇提取物混合物(200 mg/kg)的止痛作用。
结果：辣木根或叶的甲醇提取物(300 或 400 mg/kg)的止痛作用与消炎痛(5 mg/kg)类似，与对照组比较，造模后第 3 天或第 6 天用药都能够显著降低弗氏佐剂致关节炎大鼠的温度痛觉过敏程度及机械性触诱发痛程度($P<0.01$ 或 $P<0.05$)。与对照组、辣木根提取物组及辣木叶提取物组比较，造模后第 3 天或第 6 天用药，辣木根和叶的甲醇提取物混合物(200 mg/kg)能够显著降低弗氏佐剂致关节炎大鼠的温度痛觉过敏程度($P<0.01$)。
结论：辣木根或叶的甲醇提取物能够有效降低弗氏佐剂致关节炎大鼠的温度痛觉过敏程度。辣木根和叶的甲醇提取物混合物与根或叶单独的提取物的作用比较显示出辣木根与叶在止痛效果上的协同作用。

关键词：油椒木；植物提取物；镇痛药；关节炎，实验性；痛觉过敏；Freund 佐剂；大鼠