Journal of Traditional and Complementary Medicine 6 (2016) 289–293

Contents lists available at ScienceDirect

Journal of Traditional and Complementary Medicine

journal homepage: http://www.elsevier.com/locate/jtcme

Original article

Antinociceptive activity of *Euadenia trifoliolata* (Schum. & Thonn.) Oliv. leaves and roots in mice

Margaret O. Sofidiya [a, *], Opeyemi M. Oloruntola [a], Ikepo Sofola [a], Muyiwa S. Fageyinbo [b]

[a] Department of Pharmacognosy, Faculty of Pharmacy, University of Lagos, Nigeria
[b] Department of Pharmacology, Therapeutics and Toxicology, Faculty of Basic Medical Sciences, College of Medicine, University of Lagos, Nigeria

ARTICLE INFO

Article history:
Received 20 March 2015
Received in revised form
9 July 2015
Accepted 28 July 2015
Available online 19 September 2015

Keywords:
Antinociceptive activity
Euadenia trifoliolata
Capparaceae
Leaves
Roots

ABSTRACT

The leaves and roots of *Euadenia trifoliolata* are used in Nigeria traditional medicine for the treatment of ear ache, head ache and inflammation. The aim of the study was to evaluate the antinociceptive activity of ethanolic extract of the leaves (EL) and roots (ER) of *E. trifoliolata* in mice. Oral toxicity testing was performed using OECD guidelines. Antinociceptive effect was studied in mice using acetic acid-induced writhing, formalin, tail immersion and hot plate tests. Total polyphenolic contents were determined using standard methods. No mortality was recorded 24 h after oral administration of both EL and ER up to 5000 mg/kg. At the dose of 50, 100 and 200 mg/kg, administration of EL and ER resulted in significant reduction in the number of writhes compared to control. The percentage inhibition of writhings was calculated as 35.67%, 46.71% and 67.94% (EL) and 55.41%, 57.32% and 72.61% (ER), respectively. In hot plate test, EL and ER showed statistically significant antinociceptive effect, although low percentage inhibition (<50%) was recorded for ER at all the doses tested. Only EL (100 and 200 mg/kg) significantly ($p < 0.001$) increased the reaction time in tail immersion test. Both extracts significantly ($p < 0.001$) reduced the licking time in both phases of formalin test compared to control. The content of total phenolic, flavonoid and proanthocyanidin varies between the two extracts and may be the basis of the observed antinociceptive effect. The results indicate antinociceptive activity for the leaves and roots of *E. trifoliolata*, with the extract of the leaves showing better activity.

1. Introduction

Over the years, natural products have contributed enormously to the development of important therapeutic drugs used in modern medicine and one of the most important analgesic drugs employed in clinical practice today continues to be the alkaloid morphine.[1] In spite of this advancement, many traditional medicinal plants have not been scientifically evaluated in order to provide evidence of their efficacy. One of such plants is *Euadenia trifoliolata*.

E. trifoliolata (Schum. & Thonn.) Oliv. (Capparaceae) is a leafy shrub that grows up to 4 m high and is found in the dense forest in Nigeria, Gabon, Ghana and Cameroon.[2] The leaves are trifoliate, on 6 inch long or longer petioles. The leaflets are elliptical, with the central one narrowed below and the lateral leaves more or less ovate-elliptical and oblique at the base.[3]

The leaves are eaten as potherb, and a decoction of leaves is taken as a tonic and anti-anaemic. The decoction of the leaves and roots or root sap is given in nasal instillation for headache and earache and in the treatment of inflammation.[2,4] The roots emit a strong smell and are also used for the treatment of chest, kidney and general pains. Some other uses of the plant include its use in the treatment of chronic wound[5] and as mild aphrodisiac.[6]

The search for literature on this species, to the best of our knowledge, yielded no previous pharmacological and chemical reports. Moreover, we found no relevant literature substantiating the use of the plant in the management of pain. The purpose of the present study, therefore, is to evaluate the antinociceptive activity of the ethanolic extract of *E. trifoliolata* leaves and roots using different models of pain in mice.

2. Materials and methods

2.1. Plant materials

Fresh leaves (EL) and roots (ER) of *E. trifoliolata* were collected from Abatadu village, in Ikire, Osun state, Nigeria (7°30′N 4°30′E) in

* Corresponding author.
E-mail address: toyin_sofidiya@yahoo.co.uk (M.O. Sofidiya).
Peer review under responsibility of The Center for Food and Biomolecules, National Taiwan University.

http://dx.doi.org/10.1016/j.jtcme.2015.07.006

February, 2013. The plant was botanically identified and authenticated by Mr. T.K. Odewo, Herbarium unit, Department of Botany, University of Lagos, Nigeria. A voucher specimen was made and deposited at the Herbarium with voucher specimen number, LUH 5617. The leaves and roots were cleaned, air dried for 14 days and crushed into coarse powder using a grinder (Christy and Morris Limited, England).

2.2. Preparation of extracts

The extract of EL and ER was prepared by macerating 300 g and 400 g of the dried powdered samples in 1 L and 1.5 L of absolute ethanol respectively, at room temperature for 48 h. Each extract was then filtered using Whatman's filter paper and evaporated *in vacuo* at 40 °C using the rotary evaporator (Buchi, England). The yield of the extracts was 5.36% and 4.16% for EL and ER, respectively.

2.3. Phytochemical study

2.3.1. Preliminary phytochemical screening

Qualitative phytochemical screening was carried out to test for the presence of phytochemical constituents (alkaloids, tannins, saponins, anthraquinones, glycosides, flavonoids, phenols and terpenoids) using standard procedures.[7]

2.3.2. Determination of total phenolic content

Total phenol was evaluated using Folin Ciocalteu reagent.[8] The extracts (1 mg/ml, 1 ml) were mixed with 2.5 ml of Folin Ciocalteu's reagent and 2 ml aqueous Na_2CO_3 (75 g/L) solution. The mixtures were allowed to stand for 30 min, centrifuged and absorbance was recorded at 765 nm using a Pg instruments T80 UV–Vis spectrophotometer. The standard curve was prepared using gallic acid (0.01–0.05 mg/ml)) in methanol. The curve was established by plotting absorbance against concentration (mg/ml) ($y = 19.063x + 0.23642$; $R^2 = 0.9853$). Total phenol content was expressed in terms of gallic acid equivalent (GAE)/g of dried extract.

2.3.3. Determination of total flavonoid content

Total flavonoid content was determined by the $AlCl_3$ method, using quercetin as standard.[8] The test samples were dissolved in methanol. The sample solution (1 ml) was mixed with 1 ml of $AlCl_3$ (2%). After 10 min of incubation at ambient temperature, the absorbance of the supernatant was measured at 435 nm. The total flavonoid content was expressed as quercetin equivalent (QE)/g of dried extract. For the quercetin, the curve was established by plotting absorbance against concentration (mg/ml) ($y = 19.397x - 0.1196$; $R^2 = 0.9665$).

2.3.4. Determination of total proanthocyanidin content

Proanthocyanidin content was determined using the method of Sun et al.[9] The extracts (0.5 ml, 1 mg/ml) were mixed with 3 ml of 4% vanillin–methanol solution and 1.5 ml hydrochloric acid and the mixture was allowed to stand for 15 min. The absorbance was measured at 500 nm and the result presented as catechin (CE) equivalent/g of dried extract. The standard curve was prepared using catechin (0.01–0.05 mg/ml)) in methanol. The curve was established by plotting absorbance against concentration (mg/ml) ($y = 4.92x + 0.1369$; $R^2 = 0.9825$).

2.4. Animals

Albino mice (15–30 g) of male sex were used in this study. They were purchased from a private firm (Korede Farm Ltd, Ikeja, Lagos) and maintained for two weeks in the Animal House of College of Medicine, University of Lagos, Nigeria. The animals were fed with standard mouse cubes (Livestock Feed PLC, Ikeja, Lagos, Nigeria), given water ad libitum and maintained under well-ventilated conditions of 12 h light cycle. The experimental procedures used in this study conform to the United States National Institutes of Health Guidelines for Care and Use of Laboratory Animals in Biomedical Research.[10] The experiments were performed with the permission of the Institutional Animal Ethical Committee of University of Lagos (CM/COM/08/VOL.XXV).

2.5. Acute toxicity

Toxicity studies were performed for EL and ER using Organization for Economic Cooperation and Development (OECD) guidelines-420: acute oral toxicity-fixed dose procedure.[11] The animals were fasted overnight before the start of the experiment. The animals were divided into four groups of five animals and doses of extracts starting from 500, 1000, 2000 and increasing up to 5,000 mg/kg body weight were given, and signs and symptoms of toxicity were observed for the first four hours and for mortality for 24 h and further for seven days.

2.6. Evaluation of antinociceptive activity

2.6.1. Acetic acid-induced writhing test

The acetic acid-induced abdominal writhing test was performed according to the procedures described previously[12] with slight modification. One hour prior to injection of 0.6% acetic acid (10 ml/kg, i.p.), mice received EL or ER (50, 100 and 200 mg/kg, p.o.), 1% Tween 20 or acetylsalicylic acid (ASA, 100 mg/kg, p.o.). Each animal was placed in a transparent observation cage and the number of writhes per mouse was counted for 30 min. The writhing activity consists of a contraction of the abdominal muscles together with a stretching of the hind limbs. The percentage of inhibition was calculated using as follows:

$$\%\ \text{Inhibition} = \frac{(\text{mean of control} - \text{mean of treated})}{(\text{mean of control})} \times 100$$

2.6.2. Hot plate test

Pain reflexes in response to a thermal stimulus were performed at a fixed temperature of 55 ± 0.5 °C and has described by Ibrahim et al.[13] Five groups of six mice fasted overnight were used in this experiment. Pre-treatment reaction for each mouse was determined after which treatment was carried out as follows: distilled water (10 ml/kg, p.o.), morphine (10 mg/kg, s.c.) and extracts (50, 100 and 200 mg/kg). The reaction time (hind paw licking or jumping) of each mouse was then determined 60 min post-treatment. Post-treatment cut-off time of 20 s was used. Antinociceptive response expressed as percent inhibition was calculated as follows:

$$\%\ \text{Inhibition} = \frac{(\text{post-treatment latency} - \text{pre-treatment latency})}{(\text{cut-off time} - \text{pre-treatment latency})} \times 100$$

2.6.3. Tail immersion test

The tail immersion test was performed as described by Rabanal et al.[14] Before treatment, the terminal 3 cm of each mouse's tail was immersed in hot water (55 ± 0.5 °C) and the time in seconds taken to flick the tail was recorded. Only mice showing a pre-treatment reaction time less or equal to 3 s were selected for the study. Immediately after basal latency assessment, the plant extracts (50, 100 and 200 mg/kg, p.o.); morphine (3 mg/kg, s.c.) or vehicle (10 ml/kg, p.o.) were administered by the oral route to groups of 6 mice and the reaction time was again measured at 60, 90 and 120 min. Cut-off time was 10 s for tail-flick measurements in order to minimize tissue injury.

2.6.4. Formalin test

Exactly 20 μL of 1% formalin in saline was injected subcutaneously in the right subplantar region of hind paw of each mouse 1 h after oral administration of test drug solutions. Mice were kept in the observation chamber, and the time spent in licking and biting the injected paw was recorded. The first period (early phase) was recorded at 0–5 min and the second period (late phase) was recorded at 10–30 min.[15]

2.7. Statistical analysis

All results were expressed as the mean ± S.E.M. Statistical evaluation of the data was performed with Graph Pad Prism version 5.0 for Windows (GraphPad Software, San Diego, CA, USA) using one-way ANOVA followed by Tukey's Multiple Comparison Test. Differences between given sets of data were considered to be statistically significant when $p < 0.05$, $p < 0.01$ and $p < 0.001$.

3. Results

3.1. Phytochemical screening

The results of the phytochemical screening showed that both EL and ER contain glycosides, saponins and flavonoids while alkaloids, tannins and anthraquinones were not detected in both extracts. Starch was detected only in the root. The total phenol, flavonoid and proanthocyanidin content of EL were 30.00 ± 0.01 mg GAE/g, 26.53 ± 0.02 mg QE/g and 18.31 ± 0.01 mg CE/g dried extract, respectively while the content of ER were 14.00 ± 0.10 mg GAE/g, 2.96 ± 0.01 mg QE/g and −13.39 ± 0.10 mg CE/g dried extract, respectively.

3.2. Acute toxicity

The animals did not show any signs of toxicity and no mortality was recorded 24 h after oral administration of EL and ER to mice at doses 500, 1000, 2000, 5000 mg/kg.

3.3. Acetic acid-induced writhing test

The effect of EL and ER extracts on acetic acid-induced writhing in mice is shown in Table 1. Oral administration of EL and ER at the dose of 50, 100 and 200 mg/kg resulted in significant reduction in the number of writhes compared to the control. The percentage inhibition of writhings was calculated as 35.67%, 46.71% and 67.94% (EL) and 55.41%, 57.32% and 72.61% (ER), respectively. For the two extracts, the highest inhibition of abdominal constrictions was observed at the dose of 200 mg/kg body weight. Comparing the two extracts, ER had a higher antinociceptive activity than EL at all doses administered. The standard drug, acetylsalicylic acid (100 mg/kg) produced 92.78% reduction in the number of writhes compared to the control.

Table 1
Effect of *Euadenia trifoliolata* extracts on acetic acid-induced writhings in mice.

Treatment	Dose (mg/kg)	No of writhes	% Inhibition
Control	10 ml/kg	78.50 ± 2.88	–
Acetylsalicylic acid	100	5.67 ± 1.20***	92.78
EL	50	50.50 ± 3.17***	35.67
	100	41.83 ± 6.92***	46.71
	200	25.17 ± 3.98***	67.94
ER	50	35.00 ± 3.34***	55.41
	100	33.50 ± 2.92***	57.32
	200	21.50 ± 2.23***	72.61

EL: *Euadenia trifoliolata* leaves; ER: *Euadenia trifoliolata* roots. Values are mean ± SEM. (n = 6).
Data were analyzed by one-way ANOVA, followed by Tukey's post hoc test. ***$p < 0.01$ significantly different compared to the control.

3.4. Hot plate test

The results presented in Table 2 showed that EL and ER significantly increased the hot plate latency in mice. The leaves extract (EL) at doses of 50, 100 and 200 mg/kg produced a dose-dependent and significant ($p < 0.001$) antinociceptive effect, displaying percent inhibition of 33.92, 40.45 and 68.09%, respectively. On the other hand, ER increased the latency time of licking and jumping, with peak effect (29.38% inhibition) at the highest dose of 200 mg/kg. Morphine (3 mg/kg, s.c.) showed a significant antinociceptive effect (100%, $p < 0.001$) in this test.

3.5. Tail immersion test

The antinociceptive effect of EL and ER on the tail immersion test in mice is presented in Table 3. The extract of the leaves (EL) at the dose of 100 and 200 mg/kg significantly increased reaction time in the thermal stimulus. At the dose of 200 mg/kg, the effect of the extract reached a maximum of 43.38% ($p < 0.001$) at 90 min. On the other hand, the nociceptive response was not significantly ($p > 0.05$, $p > 0.01$, $p > 0.001$) affected by ER at all the doses compared to the control. Morphine (3 mg/kg, s.c.) significantly ($p < 0.001$) reduced pain response in this test.

3.6. Formalin test

Oral administration of the extracts (50, 100 and 200 mg/kg) significantly ($p < 0.001$) reduced the licking time in both phases of formalin test compared to the control (Table 4). However, EL exhibited greater effects on the early phase of the nociceptive response, while ER displayed equipotent inhibition of the two phases. The maximal inhibitions at 200 mg/kg for ER at early and late phases were 71.01% and 78.63%, respectively. Morphine exerted significant ($p < 0.001$) reduction of paw licking time in both phases of the test.

4. Discussion

The present study was conducted to assess the antinociceptive effect of the leaves and root of *E. trifoliolata*. The antinociceptive effect was evaluated on chemical nociception using acetic acid-induced writhing and formalin-induced paw licking tests and on thermal nociception in tail immersion and hot plate tests.

The abdominal constrictions produced after administration of acetic acid is considered as a visceral inflammatory pain model.[16] Acetic acid itself may cause pain; at the same time, it can also stimulate the tissue to produce several mediators such as histamine, serotonin, cytokines, and eicosanoids with an increase in peritoneal fluid levels of these mediators.[17] This test detects

Table 2
Effect of *Euadenia trifoliolata* extracts on hot plate-induced pain in mice.

Treatment	Dose (mg/kg)	Pre-treatment reaction latency (s)	Post-treatment reaction latency (s)	% Inhibition
Control	10 ml/kg	3.12 ± 0.38	3.37 ± 0.46	1.44
Morphine	3	3.88 ± 0.33	20.00 ± 0.00***	100.00
EL	50	3.65 ± 0.46	9.20 ± 0.46***	33.92
	100	4.07 ± 0.45	10.51 ± 0.86***	40.45
	200	4.63 ± 0.37	15.10 ± 0.85***	68.09
ER	50	2.23 ± 0.33	6.47 ± 0.59***	23.90
	100	1.86 ± 0.18	6.46 ± 0.22***	25.35
	200	1.63 ± 0.10	7.03 ± 0.64***	29.38

EL: *Euadenia trifoliolata* leaves; ER: *Euadenia trifoliolata* roots. Values are mean ± SEM. (n = 6).
***$p < 0.001$ vs. pre-treatment reaction latency (Student's t test).

Table 3
Effect of *Euadenia trifoliolata* on nociceptive responses in tail *immersion* test.

Treatment	Dose (mg/kg)	Reaction latency (s)			
		0 min	60 min	90 min	120 min
Control	10 ml/kg	2.66 ± 0.52	2.86 ± 0.46 (1.77)	2.57 ± 0.38 (−0.49)	2.46 ± 0.36 (−1.14)
Morphine	3	3.64 ± 0.47	1.36 ± 0.51 (94.11)***	2.75 ± 1.04 (84.74)***	16.74 ± 1.14 (80.07)***
EL	50	3.36 ± 0.34	7.51 ± 1.96 (24.95)	7.37 ± 1.53 (24.07)***	6.15 ± 1.22 (16.74)
	100	3.84 ± 0.41	5.84 ± 0.66 (12.39)***	6.12 ± 0.39 (14.12)***	5.08 ± 0.38 (7.71)**
	200	3.03 ± 0.44	8.43 ± 1.99 (31.84)***	10.39 ± 2.00 (43.38)***	7.73 ± 1.30 (27.69)***
ER	50	1.86 ± 0.19	3.38 ± 0.28 (8.44)	2.52 ± 0.09 (3.69)	1.58 ± 0.11 (−1.49)
	100	1.64 ± 0.10	3.46 ± 0.19 (9.89)	2.39 ± 0.29 (4.09)	1.43 ± 0.07 (−1.17)
	200	1.29 ± 0.08	4.17 ± 0.17 (15.35)	2.97 ± 0.20 (8.95)	1.69 ± 0.09 (2.15)

EL: *Euadenia trifoliolata* leaves; ER: *Euadenia trifoliolata* roots. Results are expressed as mean ± SEM and units are in seconds; percentage of protection against thermally induced pain by warm water are in parentheses; n = 6; **$p < 0.01$, ***$p < 0.001$, significantly different compared to the control group; data were analyzed by two-way ANOVA, followed by Bonferroni's multiple comparison test.

Table 4
The antinociceptive effect of *Euadenia trifoliolata* on formalin-induced pain in mice.

Treatment	Dose (mg/kg)	Latency time (s)		Inhibition (%)	
		Early phase (0–5 min)	Late phase (15–30 min)	Early phase	Late phase
Control	10 ml/kg	128.99 ± 8.22	134.12 ± 9.87	–	–
Morphine	3	0	0	100	100
EL	50	54.89 ± 4.78[a]	93.79 ± 4.49[a]	57.45	30.08
	100	56.40 ± 5.69[a]	84.95 ± 7.09[a]	56.28	36.67
	200	49.01 ± 4.67[a]	73.85 ± 9.66[a]	62.00	44.94
ER	50	53.52 ± 4.52[a]	46.94 ± 5.23[a]	58.51	65.00
	100	48.63 ± 4.13[a]	35.88 ± 7.51[a]	62.30	73.25
	200	37.40 ± 3.19[a]	28.66 ± 2.63[a]	71.01	78.63

EL: *Euadenia trifoliolata* leaves; ER: *Euadenia trifoliolata* roots. Results are expressed as mean ± S.E.M. n = 6 animals. The amount of time spent licking and biting the injected paw was indicative of pain and was recorded in 0–5 min (early phase) and 15–30 min (late phase). Data were analysis by two-way ANOVA, followed by Bonferroni's post hoc test. [a]$p < 0.001$, significantly different compared to the control.

peripheral analgesic activity. In this model, both EL and ER significantly inhibited mice abdominal writhes in a dose-dependent manner compared to control. This suggests potent antinociceptive activity of the two extracts which could be related to the reduction in the liberation of inflammatory mediators or by direct blockage of receptors resulting in peripheral antinociceptive effect.[18]

To check for possible central antinociceptive activity of the extracts, hot plate and tail immersion tail immersion tests were performed. The two tests are distinguished by their tendency to respond to the pain stimuli conducting through neuronal pathways.[19] Hot plate test at a constant temperature produces two kinds of responses: paw licking and jumping, which are both considered to be supraspinally integrated responses.[20] The test measures the complex response to an acute, non-inflammatory nociceptive stimulus.[12] This effect is largely dependent on central mechanism, playing an essential role in the endogenous opioid.[21] Tail immersion test, on the other hand, mediates spinal reflexes to nociceptive stimuli.[22,23] In hot plate-induced pain in mice, EL and ER showed statistically significant analgesic effect, although low percentage inhibition (<50%) was recorded for ER at all the doses used. Additionally, ER did not show antinociceptive effect in tail immersion test. These observations suggest that ER does not have centrally acting antinociceptive properties. On the other hand, the significant antinociceptive activity of EL in both hot plate-induced and tail immersion tests suggest a central action and could involve supraspinal and spinal mechanisms.

Formalin test produced a distinct biphasic response and different analgesics may act differently in the early and late phases of this test. Therefore, the test can be used to clarify the possible mechanism of antinociceptive effect of a proposed analgesic drug.[24] Centrally acting drugs such as opioids inhibit both phases equally but peripherally acting drugs such as aspirin, indomethacin and dexamethasone only inhibit the late phase. The early phase is short-lived and initiates immediately after injection, being characterized by C-fiber activation due to peripheral stimuli. The late phase on the other hand is a longer, persistent period caused by local tissue inflammation and also by functional changes in the dorsal horn of the spinal cord.[25] Experimental results

demonstrated that substance P and bradykinin participate in the early phase, while histamine, serotonin, prostaglandins, nitric oxide and bradykinin are involved in the late phase of the formalin test.[26] Our results show that the EL and ER exert significant inhibitory effect on nociceptive response of both early and late phase of formalin test, thereby attenuating the pain response similar to morphine. Moreover, the considerably higher pain suppression at the early phase than the late phase in EL indicates the centrally acting protective effect of EL which was correlated by the hot plate and tail immersion tests results.

The preliminary acute toxicity test showed no occurrence of death or abnormal behavior at 5000 mg/kg dose for either EL or ER, indicating that there may be a reasonable safety margin with regard to acute toxicity for both samples.[27]

Polyphenolic constituents are well known for their potential health benefits and have been reported to posses valuable biological activities such as antinociceptive and anti-inflammatory properties.[28,29] Additionally, Capparaceae family members contain glucosinolates, alkaloids, and flavonoids and have phytochemical composition differences in constituents from different plant parts.[30] The level of polyphenolic contents in the two extracts vary. Comparing the two extracts, EL had higher contents of total phenol, flavonoid and proanthocyanidin than ER. Differences between the extracts were highly significant ($p < 0.001$). It could therefore, be suggested that the presence of varied phytochemical constituents probably influenced the observed pharmacological differences between the two extracts.

5. Conclusion

Put together, the results of this study showed that the leaves extract (EL) and root extract (ER) of *Euadenia trifoliata* possessed significant antinociceptive effect, although the pattern of activity varied among the two extracts. Suppression of the early phase of nociception in the formalin test, significant activity observed in acetic acid-induced writhing, tail immersion and hot plate tests with EL in this study, lends credence to the centrally mediated effects of the extract. On the other hand, it could be assumed that the antinociceptive action of ER was mediated through blockade of peripheral pain pathways without the involvement of central action. The study provides evidence for the antinociceptive property of the leaves and roots of *E. trifoliolata* with the leaves extract showing better antinociceptive activity. However, there is need for further investigation of specific mechanisms of action and the active constituents of the plant. Overall, the results give scientific support for the use of the plant in the management of pain.

Conflicts of interest

None declared.

References

1. Calixto JB, Beirith A, Ferreira J, Santos ARS, Filho VC, Yunes RA. Naturally occurring antinociceptive substances from plants. *Phytother Res*. 2000;14:401–418.
2. Burkill HM. *The Useful Plants of Tropical Africa*. In: *Families A–D*. vol. 1. Kew, England: Royal Botanical Gardens; 1995:333–334.
3. Oliver D. Capparidaceae. In: Oliver D, ed. *Flora of Tropical Africa*. Ashford, United Kingdom: Reeve & Co; 1868:73–101.
4. Idu M, Obaruyi GO, Erhabor JO. Ethnobotanical uses of plants among the Binis in the treatment of ophthalmic and ENT (Ear, Nose and Throat) ailments. *Ethnobot Leafl*. 2008;13:480.
5. Agyare C, Asase A, Lechtenberg M, Niehues M, Deters A, Hensen A. An ethnopharmacological use of medicinal plants used for wound healing in Bosomtwi-Atwima-Kwanwoma area, Ghana. *J Ethnopharmacol*. 2009;125:393–403.
6. Odugbemi TT. *Outline and Pictures of Medicinal Plants from Nigeria*. 1st ed. Nigeria: University of Lagos Press; 2006.
7. Trease GE, Evans WC. *Pharmacognosy*. 15th ed. London: W.B. Saunders Company Ltd; 2002.
8. McDonald S, Prenzler PD, Antolovich M, Robards K. Phenolic content and antioxidant activity of olive extracts. *Food Chem*. 2001;73:73–84.
9. Sun JS, Tsuang YW, Chen IJ, Huang WC, Hang YS, Lu FJ. An ultra-weak chemiluminescence study on oxidative stress in rabbits following acute thermal injury. *Burns*. 1998;24:225–256.
10. NIH. *Guide for the Use of Laboratory Animals DHHS, PHS*. 1985. NIH Publication No. 85–23.
11. Organization for economic cooperation and development (OECD). *The OECD 420. Guideline for Testing of Chemicals; Acute Oral Toxicity-Fixed Dose Procedure*. 2001. Paris, France.
12. Sulaiman MR, Hussain MK, Zakaria ZA, et al. Evaluation of the antinociceptive activity of *Ficus deltoidea* aqueous extract. *Fitoterapia*. 2008;79:557–561.
13. Ibrahim B, Sowemimo A, van Rooyen A, van de Venter M. Antiinflammatory, analgesic and antioxidant activities of *Cyathula prostrata* (Linn.) Blume (Amaranthaceae). *J Ethnopharmacol*. 2012;141:282–289.
14. Rabanal RM, Bonkanka CX, Hern'andez-P'erez M, S'anchez-Mateo CC. Analgesic and topical anti-inflammatory activity of *Hypericum canariense* L. and *Hypericum glandulosum* Ait. *J Ethnopharmacol*. 2005;96:591–596.
15. Sen S, Chakraborty R, Rekha B, et al. Anti-inflammatory, analgesic, and antioxidant activities of *Pisonia aculeata*: folk medicinal use to scientific approach. *Pharm Biol*. 2013;51:426–432.
16. Ridtitid W, Sae-wong C, Reanmongkol W, Wongnawa M. Antinociceptive activity of the methanolic extract of *Kaempferia galangal* Linn. in experimental animals. *J Ethnopharmacol*. 2008;118:225–230.
17. Rinaldi S, Silva DO, Bello F, et al. Characterization of the antinociceptive and anti-inflammatory activities from *Cocos nucifera* L. (Palmae). *J Ethnopharmacol*. 2009;122:541–546.
18. Yi T, Zhao Z-Z, Yu Z-L, Chen H-B. Comparison of the anti-inflammatory and anti-nociceptive effects of three medicinal plants known as "Snow Lotus" herb in traditional Uighur and Tibetan medicines. *J Ethnopharmacol*. 2010;128:405–411.
19. Zeashan H, Amresh G, Rao CV, Singh S. Antinociceptive activity of *Amaranthus spinosus* in experimental animals. *J Ethnopharmacol*. 2009;122:492–496.
20. Santos JS, Marinho RR, Ekundi-Valentim E, et al. Beneficial effects of *Anadenanthera colubrina* (Vell.) Brenan extract on the inflammatory and nociceptive responses in rodent models. *J Ethnopharmacol*. 2013;148:218–222.
21. Ramabadran K, Bansinath M. Endogenous opioid peptides and epilepsy. *Int J Clin Pharmacol Ther Toxicol*. 1990;28:47–62.
22. Taïwe GS, Bum EN, Talla E, et al. Antipyretic and antinociceptive effects of *Nauclea latifolia* root decoction and possible mechanisms of action. *Pharm Biol*. 2011;49(1):15–25.
23. Kabir S, Zahan R, Mosaddik A, Chowdhury AMS, Haque MR, Rashid MA. Evaluation of analgesic and anti-inflammatory activities of *Polyalthia simiarum*. *Asian Pac J Trop Biomed*. 2012:1–5.
24. Lima GM, Bonfim RR, Silva MR, et al. Assessment of antinociceptive and anti-inflammatory activities of *Porophyllum. ruderale* aqueous extract. *Rev Bras Farmacogn Braz J Pharmacogn*. 2011;21(3):486–490.
25. Abdul-Wahab IR, Guilhon CC, Fernandes PD, Boylan F. Anti-nociceptive activity of *Pereskia bleo* Kunth. (Cactaceae) leaves extracts. *J Ethnopharmacol*. 2012;144:741–746.
26. Sayyah M, Hadidi N, Kamalinejad M. Analgesic and anti-inflammatory activity of *Lactuca sativa* seed extract in rats. *J Ethnopharmacol*. 2004;9:325–329.
27. Reynoso MA, Vera N, Aristimuño ME, Daud A, Riera AS. Antinociceptive activity of fruits, extracts and "arrope"of *Geoffroea decorticans* (chañar). *J Ethnopharmacol*. 2013;145:355–362.
28. Orhan DD, Hartevioglu A, Kupeli E, Yesilada E. *In vivo* anti-inflammatory and anti-nociceptive activity of the crude extract and fractions from *Rosa canina* L. fruits. *J Ethnopharmacol*. 2007;112:394–400.
29. Albano MN, daSilveira MR, Danielski LG, Florentino D, Petronilho F, Piovezan AP. Anti-inflammatory and antioxidant properties of hydroalcoholic crude extract from *Casearia sylvestris* Sw. (Salicaceae). *J Ethnopharmacol*. 2013;147:612–617.
30. Ghule BV, Murugananthan G, Alguacil LF. Analgesic and antipyretic effects of *Capparis zeylanica* leaves. *Fitoterapia*. 2007;78:365–369.