Anti-inflammatory and Analgesic Effects of *Limnophila repens* (Benth.)

*Limnophila repens* (Benth.) Anti-enflamatuvar ve Analjezik Etkileri

**ABSTRACT**

Objectives: The analgesic and anti-inflammatory effects of methanolic extract of *Limnophila repens* (MELR) were assessed at 200 and 400 mg/kg. Materials and Methods: In carrageenan-mediated paw edema, the anti-inflammatory effect of MELR was investigated and analgesic activity was assessed by central and peripheral models. Results: MELR had strong analgesic and anti-inflammatory effects at different dosages (200 and 400 mg/kg). The study results confirmed the use of *Limnophila* as both an analgesic and anti-inflammatory. The strong anti-inflammatory and analgesic effects can be caused by anabolic steroids, i.e. β-sitosterol and stigmasteryl; and flavonoids, i.e. quercetin and glycosides, in the extraction of some kind of inflamed arbitrators. Conclusion: Based on the study, we can conclude that *Limnophila repens* had analgesic and anti-inflammatory activity. In addition to organic studies, however, additional phytochemicals are required to evaluate the extra energetic chemicals responsible for the antinociceptive and anti-inflammatory effects.

**Key words:** *Limnophila repens*, carrageenan, phytochemical screening, β-sitosterol
INTRODUCTION
Herbal treatments, particularly therapeutic plants, were our ancestors’ primary or only source of healthcare. Despite the rise of the healthcare industry, therapeutic plants and medicines that can be developed from them have never been totally discarded and people still resort to traditional medicine.1 Basically, the use of natural flora in the treatment of illnesses and pain management is a key remedy.2

Limnophila is used to treat heart attacks, elephantiasis, diarrhea, dyspepsia, high temperature, dysentery, acid indigestion, dysmenorrhea, and stomach pain.3,5 Phytochemical examination of Limnophila shows a number of primary and secondary phytoconstituents.6 This variety of substances justifies the traditional use of L. repens.

L. repens is already very prevalent and frequently used in herbal remedies as an antimycobacterial, antioxidant, antineoplastic, and antimicrobial, 7-11 but no natural research studies have been performed on this herb. Subsequently, the present experiment was performed to determine the anti-inflammatory and antinociceptive activities of L. repens.

MATERIALS AND METHODS
Plant selection and authentication
During September 2017, L. repens was collected at Tirupati. Dr. K. Madhava Chetty identified and tested the examined herb. GITAM Institute of Pharmacy, Visakhapatnam, deposited an herb specimen with the voucher number 1568.

Preparation of extract
The powder (1 kg) was obtained by petroleum ether method suggested for removing both fatty and waxy materials. The methanol extract was initially extracted in alcoholic water through a splitting-up channel and then sequentially segmented together with petrol ether, chloroform, ethyl acetate, and n-butanol to obtain portions of these solvents. These extracts had been subjected to preparatory phytochemical evaluation and had, in addition, been kept in the fridge at 4°C for potential further use.12

Phytochemical screening
Various extracts of L. repens were subjected to qualitative chemical assessment using uniform criteria.13,16 Separation of phytoconstituents
Column chromatography on silica gel (60-120 mesh) using n-hexane, ethyl acetate, and 100% methanol afforded an 18 g petroleum ether portion. The fractions on the thin-layer chromatography (TLC) plate were pooled and crystallized, and named Limnophila repons (LR-1) and LR-2.17 A silica gel column eluted from the chloroform-methanol phase gradient (from 100:0 to 4:1) chromatographed the ethyl acetate section and put eight sections on their TLC. In the Sephadex LH-20, chloroform methanol (1:10) was chromatographed with methanol to provide LR-3.18 Animals
All the experimental animals used for this research were acquired from Nicholas Piramal India Limited, Mumbai. They were subsequently put in the Animal House of A.M. Reddy Memorial College of Pharmacy with IAEC Approval no. AMRMCP/05/IAEC/18-19/PHD. While in the Animal House they were allowed to consume water and eat. The animal usage complied with OECD-423 guidelines.19

Acute toxicity study
Test methanolic extract of Limnophila repens (MELR) toxicity in an acute toxicity study was based on OECD 423 recommendations for 2000 mg/kg dose. The test animals were regularly checked at 1 h, then 4 h, and finally every 24 h for 14 days for body signs and symptoms of poisoning, consisting of squirming, gulping, or pulsation as well as decreased respiratory system rate or even impermanence. No fatality was observed in this study.20

Grouping of animals and selection of dose
Furthermore, male rodents were randomly divided into four groups (control, regular, and pair of examination groups) composed of 5 animals each for analgesic and anti-inflammatory study. The first group was initially designated as the control, with 10 mL/kg distilled water. Group II specified as reference group was given the standard drug tramadol 10 mg/kg p.o. Groups III and IV received MELR (200 mg/kg and 400 mg/kg, respectively) in distilled water.

Pharmacological activity
Antinociceptive activity
The peripheral study behavior of MELR was evaluated using acetate-induced acid while the central analgesic function was investigated using the hot plate and tail-flick techniques.

Hot plate technique
Each rodent was individually placed independently on the hot plate at 55±2°C. The response time was videotaped for each mouse at 30 min, 60 min, and 90 min, monitoring medicine or vehicle administration along with 15 s cut-off to avoid injury. Increased response time and extracts were matched to the control group.21,22 Percentage of analgesic activity was calculated by using the formula

\[
\text{Percentage of analgesic activity} = \frac{(Ta-Tb) \times 100}{Tb}
\]

Ta: Average reaction time after extract; Tb: Average initial reaction time

Tail immersion test
The lower part of the rodent tail was immersed in warm water, around 55°C, which caused a painful reaction. The time, in seconds, for tail withdrawal from the water was recorded as the response period, having a cut-off time for immersion set at 15 s. The latent period of the tail immersion response was determined at 0, 30, 60, 90, 120 and 180 min after the oral administration of standard and MELR. In addition, the percentage of inhibition was calculated using the formula23
**Anti-inflammatory activity**

**Carrageen-induced paw edema**

The rat paw edema procedure caused abrupt inflammation in the rodents by administration of 0.01 mL of prepared carrageenan fluid (1% w/v) to the subplantar area. For each sample the rodents were categorized into four sections (n=5) and control and norm groups (n=5). The control group was given vehicle; the standard group received diclofenac 10 mg/kg p.o and the groups assigned for extracts received 200 and 400 mg/kg p.o. before 60 min of carrageenan injection. Upon carrageenan infusion, paw volume was assessed with an electronic plethysmometer at 1, 2, and 3 h. % Inhibition was calculated using the formula:

\[
\text{% Inhibition} = \frac{\text{Mean no. of writhes (control) - Mean no. of writhes (Treated)}}{\text{Mean no. of writhes control} \times 100}
\]

where \(T\) is Paw thickness of rats given test extract at the same time; \(T\) is Paw thickness of control rats.

**Statistical analysis**

The data are expressed as mean ± standard error of the mean (SEM). ANOVA software (GraphPad Prism 5) was used to perform the statistical analysis. The level of statistical significance was p<0.05.

**RESULTS**

**Phytochemical screening**

The results of the phytochemical analysis of different extracts are shown in Table 1.

**Characterization of LR-1**

White powder, \(C_{29}H_{48}O\), MW 412.69; IR (KBr) cm

\[^{-1}\] max: 3424 (OH stretch), 2959 (CH, CH\(_2\), and -CH\(_3\)), 2936, 2867 (C-H stretch in gem dimethyl), 1382, 1332, 1263 (C-O stretch), 1199, 1168, 1131, 1014, 959 (C-C-H bending); \(^1\)H NMR data (400 MHz, CDCl\(_3\)) 9.57 (1H, s), 9.29-9.33 (2H, d), 7.68-7.69 (1H, d), 7.53-7.69 (1H, m), 6.88-6.90 (1H, d), 5.31 (1H, d), 5.39 (1H, d), 4.61 (1H, d), 4.19 (1H, d); \(^{13}\)C NMR data (400 MHz, CDCl\(_3\)) and others: 175.81 (C-4), 163.85 (C-7), 160.70 (C-5), 156.17 (C-9), 151.17 (C-9), 147.67 (C-2), 146.81 (C-31), 145.03 (C-3), 135.68 (C-61), 121.96.

The above spectral data (mass, NMR) showed the molecular formula \(C_{29}H_{48}O\), similar to stigmasterol (Figure 1).

**LR-02**

White powder, \(C_{29}H_{48}O\), MW 414.70; IR (KBr) cm

\[^{-1}\] max: 3413 (OH stretch), 2340, 1607, 1565, 1523, 1426, 1408, 1383, 1365, 1263, 1191, 1154, 1051 (Cycloalkane), 779 cm

\[^{-1}\]; \(^1\)H NMR data (400 MHz, CDCl\(_3\)) 9.50 (1H, s), 9.29-9.33 (2H, d), 7.68-7.69 (1H, d), 7.53-7.69 (1H, m), 6.88-6.90 (1H, d), 5.33 (1H, d), 5.38 (1H, d), 4.61 (1H, d), 4.19 (1H, d); \(^{13}\)C NMR data (400 MHz, CDCl\(_3\)) and others: 175.81 (C-4), 163.85 (C-7), 160.70 (C-5), 156.17 (C-9), 147.67 (C-2), 146.81 (C-31), 145.03 (C-3), 135.68 (C-61), 121.96.

**LR-03**

Yellow powder, \(C_{15}H_{10}O\), MW 302.23; IR (KBr) cm

\[^{-1}\] max: 3413 (OH stretch), 2340, 1607, 1565, 1523, 1426, 1408, 1383, 1365, 1263, 1191, 1154, 1051 (Cycloalkane), 779 cm

\[^{-1}\]; \(^1\)H NMR data (400 MHz, CDCl\(_3\)) 9.57 (1H, s), 9.29-9.33 (2H, d), 7.68-7.69 (1H, d), 7.53-7.69 (1H, m), 6.88-6.90 (1H, d), 5.33 (1H, d), 5.38 (1H, d), 4.61 (1H, d), 4.19 (1H, d); \(^{13}\)C NMR data (400 MHz, CDCl\(_3\)) and others: 175.81 (C-4), 163.85 (C-7), 160.70 (C-5), 156.17 (C-9), 147.67 (C-2), 146.81 (C-31), 145.03 (C-3), 135.68 (C-61), 121.96.

**Acute toxicity studies**

An oral MELR dosage of 2000 mg/kg caused no immediate toxic symptoms. Furthermore, no rodents died during 24 h surveillance. The extracts have been considered to be safe at the highest allowable dose of 2000 mg/kg; the highest possible dosage was generally chosen for analgesic and anti-inflammatory activities, i.e. 200 and 400 mg/kg, 1/5th and 10-fold drops.

**Analgesic activity**

**Hot plate tests**

The mean ± SEM showed that the MELR (200 and 400 mg/kg) caused an improvement in basal reaction time from 9.62±0.22 and 9.49±0.22 at 0 min to 12.95±0.62 and 14.95±0.85 at 90 min, respectively (Figure 4, Table 2).

**Tail immersion test**

The tail immersion approach showed a marked increase of 6.39±0.15 in MELR (200 mg/kg) and 7.75±0.31 in MELR (400 mg/kg) at 180 min (Figure 5). The inhibition was the strongest at 400 mg/kg dose at 180 min, lower than normal (Table 3).

**Writhing test**

Table 4 revealed Limnophila’s peripheral pharmacological behavior on visceral squirming in mice. The control group displayed maximal writhing (26±2.12), while MELR had a strong antinociceptive effect against acetic acid-induced writhing at doses of 200 and 400 mg/kg, inhibiting pain 33.07% and 49.23% relative to carrageenan treatment at different stages. A dosage of 200 mg/kg MELR was given. MELR administered at a dose of 200 mg/kg p.o. prevented carrageenan-induced paw edema with a percentage inhibition of 19.44%, 26.61%, 33.41%, and 41.73% at 1, 2, 3, and 4 h, respectively, and 31.94%, 40.32%,
50.25%, and 61.44% at a dose of 400 mg/kg p.o. at 1, 2, 3, and 4 h, respectively. Diclofenac sodium at a dose of 10 mg/kg p.o. prevented carrageenan-induced paw edema with a percentage inhibition of 52.08%, 60.48%, 70.46%, and 73.91% at 1, 2, 3, and 4 h, respectively (Figure 7).

**DISCUSSION**

Preliminary phytochemical analysis of *L. repens* revealed many compounds including flavonoids, volatile oils, alkaloids, tannins, phytosterols, sugars, glycosides, proteins, and fixed oils.

It is well known that inflammation and pain are the most common diseases in human and animals, and the current treatment is to use steroidal and nonsteroidal anti-inflammatory drugs, which have several side effects.27,28 *L. repens* has a long history of being used for various diseases and is a well-known Indian medicine, but its analgesic and anti-inflammatory features have never been reported. We have shown important antinociceptive and anti-inflammatory behavior of *L. repens* in various animal models. The hot-plate test exemplifies centrally moderated antinociceptive responses, which typically work on modifications over a spinal-cord degree. MELR’s major discomfort-endurance implies core involvement. Some complex therapies like opiate, dopaminergic, noradrenergic, and serotonergic units usually centrally treat pain. The analgesic result due to the extract may be through major operations consisting of these types of receptors or even through specific procedures associated with prostaglandin inhibition, leukotrienes, and numerous other endogenous chemicals that may lead to swelling and discomfort.29

| Phytoconstituents       | Method              | Pet. ether extract | Chloroform extract | Ethyl acetate extract | Methanolic extract | n-Butanol extract | Aqueous extract |
|-------------------------|---------------------|--------------------|--------------------|-----------------------|-------------------|------------------|----------------|
| Flavonoids              | Shinoda test        | -                  | -                  | +                     | +                 | -                | +              |
|                         | Zn + HCl test       | -                  | -                  | +                     | +                 | -                | +              |
|                         | Lead acetate test   | -                  | -                  | +                     | +                 | -                | +              |
| Volatile oil            | Stain test          | +                  | -                  | -                     | +                 | -                | +              |
| Alkaloids               | Wagner test         | -                  | +                  | -                     | +                 | -                | +              |
|                         | Hager’s test        | -                  | +                  | -                     | +                 | -                | +              |
| Tannins and phenols     | FeCl₃ test          | -                  | -                  | +                     | +                 | +                | +              |
|                         | Potassium dichromate test | -     | -                  | +                     | +                 | +                | +              |
| Saponins                | Foam test           | -                  | -                  | -                     | -                 | -                | -              |
| Phytosterols            | Libermann’s test    | +                  | +                  | -                     | -                 | -                | -              |
| Carbohydrates           | Molish test         | -                  | -                  | -                     | +                 | -                | +              |
| Acid compounds          | Litmus test         | -                  | -                  | -                     | -                 | -                | -              |
| Glycoside               | Borntragers test    | -                  | -                  | -                     | +                 | -                | +              |
| Amino acids             | Ninyhydrin test     | -                  | -                  | -                     | +                 | -                | +              |
| Proteins                | Biuret test         | -                  | -                  | -                     | -                 | -                | -              |
| Fixed oils and fats     | Spot test           | +                  | -                  | -                     | -                 | -                | -              |
The abdominal constriction response evoked by acetic acid is a sensitive process to assess peripherally acting analgesics. Acetic acid usually induces pain by releasing endogenous components such as bradykinins, histamine, serotonin, and prostaglandins, which trigger nerve endings. Peritoneal receptors are implied to communicate with stomach constraints. The strategy also requires elevated rates of prostaglandin E2 (PGE2) and PGF2 in peritoneal and lipoxygenase materials. The major reduction in MELR-induced acetic acid writhes indicates that the analgesic activity may be moderated peripherally along with restriction of development and discharge of prostaglandins alongside endogenous drugs.

Figure 3. Structure of LR-03 (quercetin)
LR: Limnophila repens

Figure 4. Effect of MELR on hot-plate method. All the values are expressed as mean ± SEM, n=5 rat in each group, by one-way ANOVA followed by Tukey’s multiple comparison test *p<0.05 significant compared to control and #p<0.05 significant compared to standard.
MELR: Methanolic extract of Limnophila repens, SEM: Standard error of the mean

| Treatment        | Reaction time (s) | Time after treatment (min) |
|------------------|-------------------|---------------------------|
|                  |                   | 0       | 30      | 60      | 90      | 120     |
| Control          | 9.55±0.94         | 9.68±0.97 | 9.72±0.6 | 9.62±0.68 | 9.48±0.62 |
| Aspirin (100 mg/kg) | 9.34±0.11         | 17.64±0.46* | 15.84±0.39* | 12.13±0.84* | 9.71±0.54* |
| MELR (200 mg/kg) | 9.62±0.22         | 9.46±0.1* | 10.95±0.58* | 12.95±0.62* | 10.09±0.56* |
| MELR (400 mg/kg) | 9.49±0.22         | 10.72±0.38 | 12.15±0.31 | 14.95±0.85 | 10.64±0.54 |

All the values are expressed as mean ± SEM, n=5 rats in each group, by one-way ANOVA followed by Tukey’s multiple comparison test. *p<0.05 significant compared to control and #p<0.05 significant compared to standard, MELR: Methanolic extract of Limnophila repens, SEM: Standard error of the mean

Figure 5. Protective effect of MELR on tail withdrawal reflexes induced by tail immersion method in rats. All the values are expressed as mean ± SEM, n=5 rats in each group, by one-way ANOVA followed by Tukey’s multiple comparison test. Results are presented as mean ± SEM, (n=5), *p<0.05 versus control.
MELR: Methanolic extract of Limnophila repens, SEM: Standard error of the mean

Table 2. Effect of MELR on hot-plate method

| Treatment        | Reaction time (s) | Time after treatment (min) |
|------------------|-------------------|---------------------------|
|                  |                   | 0       | 30      | 60      | 90      | 120     |
| Control          | 2.31±0.06         | 2.2±0.04 | 2.42±0.11 | 2.51±0.08 | 2.56±0.08 | 2.64±0.09 |
| Aspirin (200 mg/kg) | 2.34±0.23         | 3.68±0.28 | 4.7±0.36 | 5.33±0.28 | 6.39±0.39 | 8.08±0.17 |
| MELR (200 mg/kg) | 2.03±0.07         | 2.8±0.15 | 3.6±0.22 | 4.46±0.22 | 5.4±0.16 | 6.39±0.15 |
| MELR (400 mg/kg) | 2.44±0.11         | 3.89±0.23 | 4.89±0.18 | 5.78±0.14 | 6.4±0.18 | 7.75±0.31 |

All the values are expressed as mean ± SEM, n=5 rats in each group, by one-way ANOVA followed by Tukey’s multiple comparison test. Results are presented as mean ± SEM, (n=5), *p<0.05 versus control, MELR: Methanolic extract of Limnophila repens, SEM: Standard error of the mean

Table 3. Protective effect of MELR on tail withdrawal reflexes induced by tail immersion method in rats
As an animal model for extreme swelling, carrageen-induced edema remains largely unused and is actually considered biphasic. The initial stage (1-2 h) is largely solved in cell-ruined environments by histamine, serotonin, and increased prostaglandin formation. The latter stage (3 h) is liable to release prostaglandin and regulated by tissue macrophages, bradykinin, and leukotrienes. In MELR’s late-stage, substantial suppressive activity (p<0.05) indicates its powerful anti-inflammatory effect. It is comparable to diclofenac, which prevented edema at 10 mg/kg by 61.44%, a statistically significant finding (p<0.05). Ueno et al. reported that rodent paw carrageen therapy results in bradykinin production that eventually leads to prostaglandin biosynthesis, as well as many other autacoids that accumulate inflammatory exudates. PGE2 is a dominant vasodilator with many endogenous vasodilators, notably histamine and bradykinin, in severe inflammatory environments. Extract action mode is firmly recommended to suppress prostaglandin synthesis. Tests revealed that MELR has essential anti-inflammatory properties at various stages. Carrageen-induced inflammation is an essential way to determine anti-inflammatory function. Edema formation in the rat paw following carrageen injection stems from histamine, serotonin, and prostaglandin release and associated substances. MELR has good anti-inflammatory behavior. Due to anabolic steroids, i.e. β-sitosterol and stigmasterol, flavonoids such as quercetin, and glycosides present in the extract, this significant anti-inflammatory and analgesic impact results from the inhibition of any inflammatory mediators. The latest results indicate Limnophila’s efficacy in treating acute inflammation. The result also confirms the folklore information on the anti-inflammatory and analgesic property of the L. repens extract. Yet, additional phytochemical along with pharmacological

**Figure 6.** Effect of MELR on acetic acid-induced writhing behavior in mice

1p<0.001 versus control, 2p<0.001 versus aspirin, and 3p<0.001 versus MELR (200 mg/kg).

**MELR:** Methanolic extract of Limnophila repens

**Figure 7.** Effect of MELR on carrageenan-induced paw edema method.

Results are presented as mean ± SEM, (n=5), $p<0.001 versus control; #p<0.001 versus diclofenac (10 mg/kg)

**MELR:** Methanolic extract of Limnophila repens, SEM: Standard error of the mean

| Treatment                      | Volume of Paw Edema (mm) | Time after Injection (Min) |
|-------------------------------|--------------------------|----------------------------|
| Carrageenan control (0.1 mL of 1% w/v) | 1.44 ± 0.12              | 60                          |
| Carrageenan + Diclofenac (10 mg/kg) | 2.48 ± 0.21              | 120                         |
| Carrageenan + MELR (200 mg/kg)  | 3.86 ± 0.18               | 180                         |
| Carrageenan + MELR (400 mg/kg)  | 3.45 ± 0.16               | 240                         |

**Table 4.** Effect of MELR on acetic acid-induced writhing behavior in mice

| Treatment              | Writhing count | Writhings (mean ± SEM) | % of writhing | % of inhibition |
|------------------------|----------------|-------------------------|---------------|----------------|
| Control                | 28             | 26±2.12                 | 100           | 0              |
| Diclofenac sodium (5 mg/kg) | 7             | 9±1.92                  | 31.54         | 68.46          |
| MELR (200 mg/kg)       | 16             | 20±3.57                 | 66.93         | 33.07          |
| MELR (400 mg/kg)       | 12             | 15±3.27                 | 50.77         | 49.23          |

**Table 5.** Effect of MELR on carrageenan-induced paw edema method

| Group                                      | Change in paw thickness (mm) ± SD | % Inhibition at hours |
|--------------------------------------------|-----------------------------------|-----------------------|
|                                            | 1 h                               | 2 h                   | 3 h                   | 4 h                   |
|                                            | 1 h                               | 2 h                   | 3 h                   | 4 h                   |
| Carrageenan (1% w/v of 0.1 mL)             | 1.44±0.12                         | 2.48±0.21             | 3.86±0.18             | 3.45±0.16             |
| Carrageenan + diclofenac (10 mg/kg)        | 0.98±0.15                         | 1.14±0.12             | 0.9±0.2               | 0.9±0.2               |
|                                            | 52.08                             | 60.48                 | 70.46                 | 73.91                 |
| Carrageenan + MELR (200 mg/kg)             | 1.16±0.21                         | 1.82±0.3              | 2.57±0.12             | 2.01±0.18             |
|                                            | 19.44                             | 26.61                 | 33.41                 | 41.73                 |
| Carrageenan + MELR (400 mg/kg)             | 0.98±0.14                         | 1.48±0.18             | 1.92±0.12             | 1.33±0.21             |
|                                            | 31.94                             | 40.32                 | 50.25                 | 61.44                 |

Results are presented as mean ± SEM, (n=5), 1p<0.001 versus control, 2p<0.001 versus diclofenac (10 mg/kg), MELR: Methanolic extract of Limnophila repens, SD: Standard deviation, SEM: Standard error of the mean
activity are needed to figure out the various other chemical components responsible for the anti-nociceptive and also anti-inflammatory effects.

Conflict of Interest: No conflict of interest was declared by the authors.

REFERENCES

1. Metrouh-Amir H, Amir N. Evaluation in vivo of anti-inflammatory and analgesic properties of Matricaria pubescens alkaloids. South African Journal of Botany. 2018;116:168-174.

2. Husseini Y, Sahraei H, Meftahi GH, Dargahian M, Mohammadi A, Hatif B, Zardooz H, Ranjabana M, Hosseinia SB, Alibeigb H, Behzadniaa M, Majdb A, Baharic Z, Ghoshoonia H, Jalilid C, Golmanesha L. Analgesic and anti-inflammatory activities of the hydro-alcoholic extract of Lavandula officinalis in mice: possible involvement of the cyclooxygenase type 1 and 2 enzymes. Rev Bras Farmacogn. 2016;26:102-108.

3. Les DH. Aquatic dicotyledons of North America: ecology, life history, and systematics: CRC Press; 2017.

4. Hsu H, Chen Y, Sheu S, Hsu C, Chen C, Chang H. Oriental materia medica: a concise guide. Keats Publishing; Inc; 1996.

5. Pullaiah T. Encyclopaedia of world medicinal plants: Daya Books; 2006.

6. Brahmacari G. Limnophila (Scrophulariaceae): Chemical and Pharmaceutical Aspects—An Update. The Open Natural Products Journal. 2014;7:1-14.

7. Do GD, Angkawijaya AE, Tran-Nguyen PL, Huynh LH, Soetaredjo FE, Ismadji S, Ju VK. Effect of extraction solvent on total phenol content, total flavonoid content, and antioxidant activity of Limnophila aromatica. J Food Drug Anal. 2014;22:296-302.

8. Kukongviriyapan U, Luangaram S, Leekhaosoong K, Kukongviriyapan V, Preeprame S. Antioxidant and vascular protective activities of Cratoxylum formosum, Syzygium gratum and Limnophila aromatica. J Food Drug Anal. 2014;22:177-183.

9. Rao JV, Aithal KS, Srinivasan KD. Antimicrobial activity of the essential oil of Limnophila gratissima. Fitoterapia. 1989;60:376-377.

10. Nanasombat S, Teckchuen N. Antimicrobial, antioxidant and anticancer activities of Thai local vegetables. J Med Plants Res. 2009;3:443-449.

11. Suksamrarn A, Poomsing P, Aroonrerk N, Punjanon T, Suksamrarn S, Kongkun S. Antimycobacterial and antioxidant flavones from Limnophila gratissima. Fitoterapia. 1989;60:376-377.

12. Ahmed D, Saeed R, Shakeel N, Fatima K, Arshad A. Antimicrobial activities of methanolic extract of Carissa opaca roots and its fractions and compounds isolated from the most active ethyl acetate fraction. Asian Pac J Trop Biomed. 2015;5:541-545.

13. Chavan MJ, Wakte PS, Shinde DB. Analgesic and anti-inflammatory activities of 18-acetoxy-ent-kaur-16-en from Annona squamosa L. bark. Inflammopharmacology. 2011;19:111-115.

14. Oliveira de Melo J, Truidt MCT, Muscara MN, Bolonheisa SM, Dantas JA, Caparrozo-Assaf SM, Cuman RKN, Bersani-Amado CA. Anti-inflammatory activity of crude extract and fractions of Nectandra falcifolia leaves. Biol Pharm Bull. 2006;29:2241-2245.

15. Ueno A, Naraba H, Ikeda Y, Ushikubi F, Murata T, Narumiya S, Ohishi SN. Intrinsic prostacyclin contributes to edudation induced by bradykinin or carrageenin: a study on the paw edema induced in IP-receptor-deficient mice. Life Sci. 2000;66:155-160.

16. Arumugam M, Murugan M, Thangaraj N. Evaluation of anti-inflammatory and analgesic activities of aqueous extract of Flos populi. J Ethnopharmacol. 2014;152:540-545.

17. Wan C, Yu Y, Zhou S, Tian S, Cao S. Isolation and identification of phenolic compounds from Gynura divaricata leaves. Pharmacogn Mag. 2011;7:101-108.

18. Oecd. OECD Guidelines for the Testing of Chemicals: Organization for Economic; 1994.

19. Kiran PM, Raju AV, Rao BG. Investigation of hepatoprotective activity of Cyathea gigantea (Wall. ex. Hook.) leaves against paracetamol-induced hepatotoxicity in rats. Asian Pac J Trop Biomed. 2012;2:352-356.

20. Vogel HG. Drug discovery and evaluation: pharmacological assays: Springer Science & Business Media; 2002.

21. Kumar Paliwal S, Sati B, Faujdar S, Sharma S. Studies on analgesic, anti-inflammatory activities of stem and roots of Inula cuspidata C.B Clarke. J Tradit Complement Med. 2017;7:532-537.

22. Wang YX, Gao D, Pettus M, Phillips C, Bowersox SS. Interactions of intrathecally administered ziconotide, a selective blocker of neuronal N-type voltage-sensitive calcium channels, with morphine on nociception in rats. Pain. 2000;84:271-281.

23. Xu Q, Wang Y, Guo S, Shen Z, Wang Y, Yang L. Anti-inflammatory and analgesic activity of aqueous extract of Flos populi. J Ethnopharmacol. 2014;152:540-545.

24. Farouk L, Laroubi A, Aboufatima R, Benharref A, Chait A. Evaluation of anti-inflammatory and analgesic effects of aqueous extract obtained from root powder of Inula racemosa Hook. J. Med Plants Res. 2012;6:2801-2806.

25. Collier HO, Dinneen LC, Johnson CA, Schneider C. The abdominal constriction response and its suppression by analgesic drugs in the mouse. Br J Pharmacol Chemother. 1968;32:295-310.

26. Deraedt R, Jouquey S, Delevallée F, Flahaut M. Release of prostaglandins E and F in an algogenic reaction and its Inhibition. Eur J Pharmacol. 1980;6:17-24.

27. Millan MJ. Descending control of pain. Prog Neurobiol. 2002;66:355-474.

28. Collier HO, Dinneen LC, Johnson CA, Schneider C. The abdominal constriction response and its suppression by analgesic drugs in the mouse. Br J Pharmacol Chemother. 1968;32:295-310.

29. Chavan MJ, Wakte PS, Shinde DB. Analgesic and anti-inflammatory activities of 18-acetoxy-ent-kaur-16-en from Annona squamosa L. bark. Inflammopharmacology. 2011;19:111-115.

30. Oliveira de Melo J, Truidt MCT, Muscara MN, Bolonheisa SM, Dantas JA, Caparrozo-Assaf SM, Cuman RKN, Bersani-Amado CA. Anti-inflammatory activity of crude extract and fractions of Nectandra falcifolia leaves. Biol Pharm Bull. 2006;29:2241-2245.

31. Ueno A, Naraba H, Ikeda Y, Ushikubi F, Murata T, Narumiya S, Ohishi SN. Intrinsic prostacyclin contributes to edudation induced by bradykinin or carrageenin: a study on the paw edema induced in IP-receptor-deficient mice. Life Sci. 2000;66:155-160.

32. Simplice FH, Arm AB, Roger P, Emmanuel AA, Pierre K, Veronica N. Effects of Hibiscus asper leaves extracts on carrageenan induced oedema and complete Freunds adjuvant-induced arthritis in rats. Journal of Cell and Animal Biology. 2011;5:66-68.

33. Georgewill O, Georgewill U, Nwankwoala R. Anti-inflammatory effects of Morninga oleifera lam extract in rats. Asian Pac J Trop Med. 2010;3:133-135.
36. Winter CA, Risley EA, Nuss GW. Carrageenin-Induced Edema in Hind Paw of the Rat as an Assay for Anti-inflammatory Drugs. Proc Soc Exp Biol Med. 1962;111:544-547.

37. Georgewill OA, Georgewill UO. Evaluation of the anti-inflammatory activity of extract of Vernonia amygdalina. Asian Pac J Trop Med. 2010;3:150-151.

38. Saeidnia S, Manayi A, Gohari AR, Abdollahi M. The story of beta-sitosterol-a review. European J Med Plants. 2014;4:590.

39. Li Y, Yao J, Han C, Yang J, Chaudhry MT, Wang S, Liu H, Yin Y. Quercetin, Inflammation and Immunity. Nutrients. 2016;8:167.