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Quantitative analysis of medicinal plants used to treat musculoskeletal ailments by non-institutionally trained siddha practitioners of Virudhunagar district, Tamil Nadu, India

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A B S T R A C T

Background: Siddha is one of the traditional medical systems of India; previous ethnobotanical survey in Virudhunagar district indicated a high consensus for treating musculoskeletal ailments.

Objectives: This study was aimed to quantitatively document the medicinal plants used to treat musculoskeletal ailments by non-institutionally trained siddha practitioners of Virudhunagar district, Tamil Nadu, India.

Materials and methods: This work was the outcome of free-list interviews conducted among 45 informants between April 2016 and January 2017. Sampling sufficiency was assessed by plotting Shannon–Wiener’s index and cumulative number of UR. Informant consensus was assessed using Informant Consensus Factor (Fic) and Informant Agreement Ratio (IAR).

Results: This study recorded the data regarding 116 plant species which were used to prepare 129 formulations; analysis of the data yielded 490 UR. Among these, 65.3% of UR dealt with internal applications and 34.6% dealt with external applications. In the case of internally used formulations, pain and general musculoskeletal ailments had high Fic values. In the case of externally used formulations, headache and pain had high Fic values.

Conclusion: Important species prescribed by the informants to treat various musculoskeletal ailments were: Azima tetractantha, Ricinus communis, Sesamum indicum, Moringa oleifera, Cardiospermum halicacabum (internal application), Calophyllum inophyllum, Justicia adhatoda, Curcuma longa, Calotropis gigantea, Zingiber officinalis, Withania somnifera, Strychnos nux-vomica, Dodonaea viscosa (external application), Azadirachta indica, Clerodendrum phlomidis, Delonix elata, Pergularia daemia and Vitex negundo (internal and external applications). Robust studies on these local claims will help to improve the community healthcare and will yield some novel agents to treat musculoskeletal ailments.

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1. Introduction

Traditional medicine system is defined as the accumulated therapeutic experiences of generations [1]; it is still used by about 75–80% of the world population for primary health care [2]. In India various traditional healthcare systems are available and it includes the use of about 7000 species of flowering plants [3]. Siddha is one of the important traditional medical systems of India majorly practiced in Tamil Nadu and its fringes [4]; it is also practiced in other countries such as Sri Lanka, where the Tamil people live.

According to the siddha doctrine, the human body is made up of 96 principles (thattuvam). Among them, three humors namely vātā (≈ air), pitta (≈ fire) and kapha (≈ water) are considered as important principles for health. Any imbalance among them causes illnesses. The vātā humor maintains all the movements of the body, such as movement of organs, reflexes, functional co-ordination, etc. Any derangement in this humor in a particular organ will show the characteristics of pain, debility, tremor, rigidity and loss of

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function in the related organs and these changes are termed as vata ailments. Siddha literature describe about eighty five types of vata diseases [5,6]; most of them were the musculoskeletal ailments and few other illnesses like hernia were also categorized under this group in the traditional literature. These ailments are one of the important illnesses treated by the siddha system of medicine; our previous study in the same area showed high informant consensus for this illness category [7].

Musculoskeletal disorders (MSD) are the second largest cause of disability [8], impacting the individuals and their prevalence is increasing with age [9]. The prevalence of MSD in India was calculated as 6.4–23.6% [10] and it was the most common self-reported illness. Two-third of MSD subjects in India were reported to suffer from non-specific pain and arthralgia [11]. An US based survey between 1992 and 2010 indicated that MSD accounted for about 29–35% of all occupational illnesses involving days away from work [12]. According to a survey musculoskeletal pain nearly affects one in every four adults and the annual cost of managing pain ranged from $560 to $635 billion dollars for the United States [13]. Further, MSD was identified as one of the most common causes for seeking self-medication. The use of complementary and traditional therapies in the management of MSD is reasonably common globally and a survey in India conducted among dentists indicated that about 70% of subjects with MSD use only these alternate therapies [14].

The importance of training traditional healers for the management of MSD in India was also reported by previous studies [15]. In this survey, we quantitatively documented the medicinal plants used by the non-institutionally trained siddha practitioners of Virudhungar district to treat the musculoskeletal ailments. It also documented the formulations for few non-MSD like hernia, testicular pain since they were also considered as one among the vata ailments.

2. Methodology

2.1. Study area

Virudhungar district is located in Tamil Nadu with an area of 4288 km² (Fig. 1). It is bounded by Madurai, Thoothukudi and Theni districts in Tamil Nadu and by Kerala state in the west. The district has a mixture of rural and urban populations; the rural population is 49.5%. This district comprises eight taluks (sub-districts) namely Aruppukottai, Kariapatti, Thiruchuli, Rajapalayam, Srivilliputtur, Sivakasi, Sattur and Virudhungar. The population density of this district is 458 inhabitants/km² and the gender ratio for females to males is 1.7:1.0. The total literacy rate of Virudhungar district is 80.1%; the female literacy rate is 65.5%. Forests in this district are found on the eastern slopes of the Western Ghats and they occupy only 6.3% of geographical area of this district. Agriculture is the major source of revenue in rural parts, while printing and cracker only 6.3% of geographical area of this district. Agriculture is the

2.2. Interviews

The field survey was conducted from April 2016 to January 2017. The non-institutionally trained siddha practitioners were identified with the help of the elders in the study area. Only the practitioners who were treating musculoskeletal ailments for more than five years and gave consent to participate in the interview were included in the survey. The aims and objectives of the study were explained in lay terms before the start of the interview and the informants were explained that they had the right to stop the interview at any time. The first two visits were used to explain these details and the formal interviews were conducted from the subsequent visits [16]. All the protocols were reviewed and approved by the Institutional Ethics Committee for Ethnobiology Research (ERI/IEEC/15/02) and the field surveys were conducted by SE, SM and PP. This interview includes the ethnomedical data obtained from 45 non-institutionally trained siddha practitioners of Virudhungar district who gave written consent to share their knowledge.

The methodology used for this study is successive free-listing method [17] to collect the data. The questionnaire consisted of two parts. The first part dealt with the demography of the informants and the second part dealt with their knowledge on the medicinal plants used for treating musculoskeletal ailments. In the second part, the informants were asked about the formulations given to treat musculoskeletal ailments, their ingredients, parts used with measures, mode of preparation, illnesses treated with their symptomatology, dose and duration; all these were documented. The interviews and the data were gathered through the local language, Tamil and the data were translated into English in the laboratory. Equivalent English terms for the illnesses were fixed by correlating the Tamil terminologies and symptoms with the biomedical literature by one of the authors of this communication (PE), who is an institutionally trained siddha practitioner.

2.3. Specimens

Collected plant specimens or raw drugs were identified through examination of voucher specimens and the binomial names for the species were fixed using local florals [18–21] and the valid correct names were confirmed with a website (http://www.theplantlist.org/). The plant specimens and raw drugs were stored at the herbarium of Entomology Research Institute, Loyola College, Chennai.

2.4. Data analysis

The illnesses were grouped into illness categories on the basis of siddha literature. The data on medicinal plants were converted into use-reports (UR) in accordance with the previously published methodology [22]. Sampling sufficiency of the survey was assessed by plotting Shannon Wiener’s index, which was calculated using PAST3 program; cumulative number of use-reports and attaining a clear asymptote of the curve are considered indicators of sampling sufficiency. The data were grouped into external and internal formulations. Informant consensus factor (Fic) was calculated for external and internal formulations separately under each illness category using the following formula.

\[
F_{ic} = \frac{(N_{ur} - N_{i})}{(N_{ur} - 1)}
\]

Where \(N_{ur}\) is the number of UR for a particular illness category, and \(N_{i}\) is the total number of species mentioned for that particular illness category. This factor ranges from zero to one, where increasing values indicate high rate of informant consensus. To assess the importance of individual species in each illness category Index of Agreement on Remedies (IAR) was calculated using the following formula

\[
\text{Index of Agreement on Remedies (IAR)} = \frac{n_{ur} - n_{dl}}{n_{r} - 1}
\]

Where \(n_{ur}\) is the total number of UR registered for species and \(n_{dl}\) is the number of illness categories that are treated with that species.
3. Results

3.1. Demography of the informants

Analysis of the demography of the informants indicated that 78% of the informants were above 50 years of age and all are belonging to male gender. All informants completed only primary or secondary school education. The major way of non-institutional knowledge transmission was master and disciple method; all the informants were full time practitioners and 67% of the informants had >20 years of experience (Table 1).

3.2. Quantification of the data

This survey is the outcome of 45 interviewing non-institutionally trained siddha practitioners of Virudhunagar district of Tamil Nadu. The data regarding the different musculoskeletal ailments closely related English terms and illness categories under which they are grouped are given in Table 2. The data regarding the formulations used by the informants to treat various musculoskeletal ailments are given in Table S1. Plotting species richness curve indicated that the sampling was sufficient for data analysis (Fig. 2). This study recorded the data regarding 129 traditional siddha formulations used to treat various musculoskeletal ailments and analysis of the data yielded 490 UR. Among these UR, 320 (65.3%) dealt with internal applications and 170 (34.6%) dealt with external applications. Conversion of UR to claims yielded 345 claims and 231 (66.9%) claims dealt with internal uses. Only 25 (10.8%) and 20 (17.5%) claims had minimum two URs for internal and external uses, respectively. The rest of the claims were singletons (Tables 3 and 4).

This study recorded the use of 116 species to treat various musculoskeletal ailments. Among them, 49 (42.2%) species were reported for internal uses; 32 (27.5%) were reported for external uses and 35 (30.1%) were reported for both external and internal
uses. In the case of species used only internally, Plumbago indica had high number of UR. In the case of species used only for externally usage, Cocos nucifera had high number of UR. Zingiber officinale had high number of UR in the case of plants used both externally and internally. The illness categories were grouped arbitrarily into three groups viz., illness categories having high, average or low Fic values [23,24]. The illness category, pain had highest overall Fic value, followed by general musculoskeletal ailments.

3.3. Quantification of internally used formulations

In this category, pain and general musculoskeletal ailments had obtained high Fic values, compared to the others. The illness categories like flatus, stiffness, vātā of scrotal region, paresis and spasm had average Fic values. Z. officinale obtained 12 UR for pain followed by Allium sativum. In the illness category of pain, the plants such as Saussurea costus, Senna auriculata and Delonix elata had high IAR values. In the case of plants given to treat general musculoskeletal ailments Piper nigrum, Z. officinale and A. sativum also got high number of citations. In this category, Clerodendrum phlomidis, D. elata and Vitex negundo had high IAR values. The plants with high number of citations for illness categories with average Fic values were: P. nigrum (flatus and stiffness), A. sativum (vātā of scrotal region), Azima tetracantha (paresis) and Z. officinale (spasm). The remaining illness categories got low Fic values.

3.4. Quantification of externally used formulations

In the case of externally applied formulations, headache got high Fic value followed by pain and general musculoskeletal ailments. Swelling and arthritis had average Fic values. In the case of headache, coconut oil was used to prepare many formulations and got

| Table 1 | Demographic profile of the informants shared their knowledge for this study. |
|---------|--------------------------------------------------------------------------------|
| Attributes | Number | Percentage |
| Age | | |
| 45–50 | 10 | 22.22 |
| 51–60 | 18 | 40 |
| 61–65 | 10 | 22.22 |
| Above 66 | 7 | 15.55 |
| Gender | | |
| Male | 45 | 100 |
| Primary school | 16 | 35.55 |
| Secondary school | 29 | 64.44 |
| Mode of learning | | |
| From family members | 12 | 26.66 |
| From traditional practitioners | 33 | 73.33 |
| Experience | | |
| 20 years | 15 | 33.33 |
| 21–30 | 10 | 22.22 |
| 30–45 | 20 | 44.44 |
| Occupation | | |
| Full time practitioners | 45 | 100 |

| Table 2 | Local terminologies of various musculoskeletal ailments reported by the informants with equivalent English terms. |
|---------|--------------------------------------------------------------------------------|
| S. No. | Local Name | Equivalent English terms | Illness category |
| 1 | An̄tvātām | Inflammation and swelling of the testicles | vātā of scrotal region |
| 2 | Aṟampā vātunāy | Early stage of musculoskeletal ailments | General musculoskeletal ailments |
| 3 | Inppuvali | Lumbosacral pain | Pain |
| 4 | Ilampūkai vātām | Poliomyelitis | Poliomyelitis |
| 5 | UppuVali | Body pain | Pain |
| 6 | Orupakkut talaivali | Hemicrania | Pain |
| 7 | Kāṭṭuvali | Pain in the neck | Pain |
| 8 | Kāḷvali | Pain in the leg | Pain |
| 9 | Kūvātām | Arthralgia | Arthritis |
| 10 | Kūtalvalam | Hernia | Hernia |
| 11 | Kāṭṭīkal | Naising pain | Pain |
| 12 | Kaḷ, kāḷ kūṭiical | Naising pain of all the limbs | Pain |
| 13 | Kaḷ, kāḷ vali | Pain in upper and lower limbs | Pain |
| 14 | Carvānka vātām | Quadriplegia | Paresis |
| 15 | Ĉūai | Lancing pain | Pain |
| 16 | Talavali | Headache | Pain |
| 17 | Timavātām | Spasm resulting from numbness | Spasm |
| 18 | Tōppiţappiţppu | Rheumatism of the Shoulder | Rheumatism |
| 19 | Nōkkvalvalam | Parkinsonism | Parkinsonism |
| 20 | Nōrampappiţppu | Contraction of a nerve or muscle | Spasm |
| 21 | Pokavātām | Hemiplegia | Paresis |
| 22 | Pariccayā | Paresis | Paresis |
| 23 | Piṭṭi icīv | Spasm in the shoulder | Pain |
| 24 | Piṭṭivali | Pain in occipital region | Pain |
| 25 | Piṭṭpu | Stiffness | Stiffness |
| 26 | Maṅtiikkattu | Boring headache | Pain |
| 27 | Mūṟpuvali | Chest pain | Pain |
| 28 | Muṅkkavātām | Arthritis | Arthritis |
| 29 | Muṅkāḷ vali | Pain in the knees | Pain |
| 30 | Maṅcuppippu | Pain during breathing | flatus |
| 31 | Muṅṭṭuvali | Pain in the joints | Pain |
| 32 | Vātā aḷḷci | Inflammation due to vitiated vātā humour | Inflammation |
| 33 | Vāṭu vali | Pain due to vitiated vātā humour | Pain |
| 34 | Vāṭu vikkam | Swelling due to vitiated vātā humour | Swelling |
| 35 | Vāṭakkattappu | Pain due to vitiated vātā humour | Pain |
| 36 | Vāṭam aḷḷcittu | All types of vātā ailments | General musculoskeletal ailments |
| 37 | Vīḷyuppiţppu | Stiffness due to flatus | flatus |
| 38 | Vīḷai vikkam | Testicular swelling | Vāṭu of scrotal region |
| 39 | Vīḷai vakkam | Pain in testicles | Vāṭu of scrotal region |
| 40 | Vikkam | Oedema | Swelling |
high number of UR. The plants such as *Curcuma longa*, *Gmelina asiatica*, *V. negundo*, *Sesamum indicum*, *Z. officinalis* and *Calotropis gigantea* had high IAR values in this group. In the case of pain, the oils of *Ricinus communis* and *Azadirachta indica* had high Fic values for external applications. The plants such as *Withania somnifera*, *Dodonaea viscosa* and *C. phlomidis* had high IAR values for the treatment of pain. In the case of plants prescribed for general musculoskeletal ailments, *C. phlomidis* had high number of UR and *Justicia adhatoda* had high IAR value.

4. Discussion

Many ethnobiological surveys indicated a positive correlation between the age and increased knowledge on traditional medicine. The informants of this survey indicated that most of the informants were above 50 years of age and had above 20 years of experience. Our previous survey in the same study area documented that this practice was majorly a male dominant domain and it was also reflected in this survey. The master to disciple mode of knowledge transmission was predominant in this system than father to son knowledge transmission. During the field work, it was noticed that few disciples were working with the informants and they were allowed to observe and assist the informants in collecting herbs, preparing the formulations and treatment.

Low back pain and chronic joint pain were reported as the most common musculoskeletal conditions [25] and their prevalence was increasing with age [26]. An UK based study showed that NSAIDs were taken by one in every few people between the ages 65 and 74 for the management of pain [27]. In India, the use of analgesics particularly herbal based were reported as the first choice by the patients for the management of pain [28].

This survey reported the high use of *P. nigrum*, *Z. officinalis* and *A. sativum* for the management of general musculoskeletal ailments, pain, stiffness of joints and flatus. Ginger is also reported as an anti-inflammatory herb in *Ayurveda* and Chinese systems of traditional medicine. The major phytochemical constituents of ginger such as gingerols and shogalos were reported to interfere with leukotriene, interleukins, cyclooxygenase and TNF-α metabolisms [29]. A small, randomized controlled trial with 43 subjects with osteoarthritis indicated that the supplementation with ginger based combination significantly reduced the pain and had gastro protective effect, compared to diclofenac [30]. Another double-blind randomized clinical trial with 440 patients with systematic osteoarthritis also indicated that the supplementation of a ginger containing formulation for 24 weeks significantly reduced pain and improved knee function [31]. Short term study with normal subjects indicated that ginger supplementation did not affect the visual analog scale of pain [32]. Though studies showed a reduction in the subjective experience of pain with ginger supplementation, robust studies are needed to establish the analgesic activity of ginger [29]. No clinical reports were available for the analgesic effect of garlic.

Some studies were conducted on the species such as *P. nigrum*, *Moringa oleifera* and *R. communis* cited by the informants for the management of pain. A small, double-blind randomized clinical trial with 54 patients with systematic osteoarthritis indicated that the supplementation of essential oil of *P. nigrum* for nine weeks significantly reduced pain [33]. Some preclinical experiments also reported the analgesic effect of pepper and piperine [34]. Likewise, few animal reports indicated the analgesic effect of *M. oleifera* [35,36]; however no clinical report was available. A small, randomized clinical trial with 30 patients with systematic osteoarthritis indicated that the supplementation of root powder of *R. communis* for 30 days significantly reduced pain [37]. In the illness category pain, *S. costus* and *S. auriculata* had high IAR values; however no clinical data is available on the efficacy of these two species. Some anti-inflammatory constituents such as 3,4-dihydrobenzoic acid from *V. negundo* [38], 3-hydroxy, 2-methoxysodium butanoate [39] and hesperidin from *D. elata* [40] were also reported; however these plants lack rigorous studies.

A preclinical experiment with nitroglycerine induced migraine in rats indicated the beneficial effect of oral curcumin treatment [41]. In a double blind placebo controlled study with 60 adult migraine subjects indicated the use of oral ginger treatment [42]. In subjects with chronic osteoarthritis, topical ginger application

![Fig. 2. Assessing sampling sufficiency using species accumulation curve.](image-url)
reflected the symptoms and increased the independence [43]. In many traditional systems of medicine the uses of V. negundo [41] and Calotropis procera [44] to treat headache and painkillers have been reported as one of the widely used formulations, having better pain relief with minimal adverse events compared to the oral anti-inflammatory agents [46]. This study indicated the use of many plants topically for the management of musculoskeletal ailments. There were scientific evidences and traditional literature support for these species; however scientific studies were limited for their external usage.

5. Conclusion

Studies showed that the global mortality rates were fallen while the rate of disability adjusted life years (DALF) is increasing dramatically. Musculoskeletal disorders such as low back pain are the important causes for the increase of DALF, which in turn impaired the quality of life and loss in working ability. The use of complementary therapies for the management of musculoskeletal health conditions were reported as high, particularly among the veterans and there is a need to scientifically evaluate the traditional claims. The species such as A. tetrandra (pareisis), R. communis, Sesamum indicum (general musculoskeletal ailments), M. oleifera and Cardiopermum halicacabum (pain) were reported to be used internally to treat various musculoskeletal ailments. The species such as Calophyllum inophyllum (arthritis), Justicia adhatoda (general musculoskeletal ailments), Curcuma longa, Calotropis gigantea, Zingiber officinale (headache), Withania somnifera, Strychynos nux-vomica and Dodonaea viscosa (pain) were reported for external applications to treat musculoskeletal disorders. The species such as Azadirachta indica, Clerodendrum philomidi, Delonix elata, Pergularia daemland Vex negundo were reported for both internal as well as external uses. This study showed that many of the claims were limited clinical evidences and it is important to conduct well-planned, scientifically robust studies to establish the efficacy and safety of these treatments. This study documented that a considerable portion of plants were used externally. Scientific evidences were little for their external application and further robust studies on these claims will yield some novel topical agents for the management of musculoskeletal ailments.

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Conflict of interest

None.

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Appendix A. Supplementary data

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References

[1] Kamboj JP. Herbal medicine. Curr Sci 2000;78(1):35–9.
[2] Majaz AQ, Khursheed IM. Herbal medicine: a comprehensive review. Int J Pharm Pharmacol 2016;8(2):1 S.
[3] Mukherjee PK. Evaluation of Indian traditional medicine. Drug Inf J 2001;35:623–32.
[4] Shukla SS, Saraf S, Saraf S. Fundamental aspects and basic concepts of Siddha medicines, vol. 2. 2011; p. 48–54.
[5] Mudaliar KNK. Siddha maruthuvang churukkam, vol. 6. Chennai: Govt. of Tamil Nadu, Department of Indian Medicine and Homeopathy; 2005. p. 103.
[7] Matheeswaran S, Pandikumar P, Chellappandan M, Ignacimuthu S. Documentation and quantitative analysis of the local knowledge on medicinal plants among traditional Siddha healers in Virodhurangar district of Tamil Nadu, India. J Ethnopharmacol 2011;137(1):523 33.
[8] Marks D, Comans T, Bisset L, Scuffham PA. Substitution of doctors by physiotherapists in the management of common musculoskeletal disorders: a systematic review. Physiotherapy 2017;103(4):341 51.
[9] Oakman J, Rothmore P, Tappin D. Intervention development to reduce musculoskeletal disorders: is the process on target? Appl Ergon 2016;56:179–86.
[10] Misra DP, Agarwal V, Negi VS. Rheumatology in India: a bird's eye view on organization, epidemiology, training programs and publications. J Kow Med Sci 2016;31(7):1013 19.
[11] Chopra A. The COPCORD world of musculoskeletal pain and arthritis. Rheumatology 2013;52:1923–8.
[12] Bhattacharya A. Costs of occupational musculoskeletal disorders (MSDs) in the United States. Int J Ind Ergon 2014;44:448–54.
[13] Tompkins DA, Hobelmann JG, Compton P. Providing chronic pain management in the Fifth Vital Sign Era: historical and treatment perspectives on a modern-day medical dilemma. Drug Alcohol Depend 2017;173:511 21.
[14] Gupta D, Mathur A, Patil GI, Tippanawar HK, Jain A, Jaggi N, et al. Prevalence of musculoskeletal disorder and alternative medicine therapies among dentists of North India: a descriptive study. Pharmacogn Res 2015;4:350–4.
[15] Sharma R, editor. Epidemiology of musculoskeletal conditions in India. New Delhi, India: Indian Council of Medical Research; 2012.
[16] Heinrich M, Lardos A, Leonti M, Weckerle C, Willcox M. With the ConSEFS Advisory Group. Best practice in research: consensus statement on ethnopharmacological field studies: a critical assessment of their conceptual basis and methods. J Ethnopharmacol 2009;124:17.
[17] Gamble JS. The flora of the presidency of madras. Reprinted edition, vols. I–III. Dehra Dun: Bishen Singh–Mahendra Pal Singh; 1997.
[18] Nair NC, Henry AN. Flora of Tamil Nadu, India, vol. I. Coimbatore: Botanical Survey of India, Southern Circle; 1983.
[19] Henry AN, Chithra V, Balakrishnan NP. Flora of Tamil Nadu, India, vol. III. Coimbatore: Botanical Survey of India, Southern Circle; 1989.
[20] Henry AN, Kumari GR, Chithra V. Flora of Tamil Nadu, India, vol. II. Coimbatore: Botanical Survey of India, Southern Circle; 1983.
[21] Chopra A, Saluja M, Tillu M, Sarmukkadem S, Venugopal A, Narsimulu G, et al. Ayurvedic medicine offers a good alternative to glucosamine and celecoxib in the treatment of symptomatic knee osteoarthritis: a randomized, double-blind, controlled equivalence drug trial. J Rheumatol 2013;52:1408–17.
[22] Matsumura MD, Zavorsky GS, Smoliga JM. The Effects of Pre-Exercise Ginger supplementation on muscle damage and delayed onset muscle soreness. Phytother Res 2015;29(6):887–93.
[23] Costa R, Machado J, Abreu C. Evaluation of analgesic properties of Piper nigrum essential oil: a randomized, double-blind, placebo-controlled study. World J Tradit Chin Med 2016;2(2):60 4.
[24] Rasheed F, Azhar I, Ali NS, Perveen S, Mahmood ZA. Analgesic and anti-inflammatory activities of Piper nigrum L Asian Pac J Trop Med 2014;7(1):461–8.
[25] Mananji H, Jafari S, Zaringhalam J, Rezaazadeh S, Taghizadifar R. Analgesic effect of methanolic extracts of the leaf or root of Moringa oleifera on complete Freund's adjuvant-induced arthritis in rats. Chin J Integr Med 2011;9(2):216–22.
[26] Martinez-Gonzalez CL, Martínez L, Martínez-Ortiz EJ, Gonzalez-Trujanoa ME, Deciga-Camposc M, Ventura-Martínez R, et al. Moringa oleifera, a species with potential analgesic and anti-inflammatory activities. Biomed Pharmacother 2017;87:482 8.
[27] Saban B, Seema GC. Comparative clinical study of Ricinus communis (Eranda) in management of sandhigatavata (osteoarthritis). World J Pharm Sci 2015;4(5):832–40.
[28] Rasadah MA, Farediah A, Wong KL, Ong BK. Anti-inflammatory activity of extracts and compounds from Vetex negundo. J Trop For Sci 2005;17(4):481 7.
[29] Babu NP, Saravanavan S, Pandikumar P, Balakrishna R, Raj MK, Ignacimuthu S. Anti-inflammatory and anti-arthritic effects of 3-hydroxy, 2-methoxy sodium butanoate from the leaves of Clerodendrum philomidisi L. Inflamm Res 2014;63:127–38.
[30] Saravanavan S, Islam VIH, David HA, Lakshmisundaram R, Chellappandan M, Balakrishna K, et al. Bioassay guided fractionation and identification of active anti-inflammatory constituent from Delonix elata flowers using RAW 264.7 cells. Pharm Biol 2014;52(2):174 84.
[31] Yabesh JE, Prabhu S, Vijayakumar S. An ethnobotanical study of medicinal plants used by traditional healers in silent valley of Kerala, India. J Ethnopharmacol 2014;154:774–89.
[32] Martins LB, Rodrigues AMS, Rodrigues DF, Santos LC, Teixeira AL, Ferreira AVM. Double-blind placebo-controlled randomized clinical trial of ginger (Zingiber officinale Rosc.) addition in migraine acute treatment. 2018: p. 1–9. 0(0).
[33] Therkleson T. Topical ginger treatment with a compress or patch for osteoarthritis symptoms. J Holist Nurs 2013;32:173–82.
[34] Veena R, Satangi G, Shrivastava J. Ethno-medical profile of different plant parts of crotopsis procer (Al.) R Br Ethnobotanical Leaflets. 2010;14:721–42.
[35] Ramakanth G, Kumar CU, Kishan P, Usharani P. A randomized, double blind placebo controlled study of efficacy and tolerability of Withania somnifera extracts in knee joint pain. J Ayurveda Integr Med 2016;7(3):151–7.
[36] Derry S, Moore RA, Gaskell H, McIntyre M, Wiffen PJ. Topical NSAIDs for acute musculoskeletal pain in adults. Cochrane Database Syst Rev 2015;6:CD007402.