Journal of Applied Pharmacognosy and Phytochemistry
Volume 1, Issue 1, Year of Publication 2021, Page 15 – 21

Research Article

JOURNAL OF APPLIED PHARMACOGNOSY AND PHYTOCHEMISTRY | JOAPP
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EVALUATION OF PRELIMINARY PHYTOCHEMICAL AND IN VITRO ANTIOXIDANT ACTIVITY OF HOMALOMENA AROMATICA (TUBER)

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Article Information
Received: 24th May 2020
Revised: 26th November 2020
Accepted: 19th December 2020

Keywords
Homalomena aromatica, tuber, essential oils, therapeutic indication, antioxidant activity

ABSTRACT
Homalomena aromatica, also called as sugandhimantri which has a local name gansena, it is a small plant with large stem and aromatic in nature which is basically found in the northeast of india. The plant has a mesmerizing aroma that makes widely used in aromatherapy applications. The tuber are known to possess medicinal properties like anti-inflammatory, analgesic, antidepressant, antiseptic, sedative, antispasmodic, treating joint pain, and skin infections. Not only tuber has medicinal value, but the roots, rhizome, stem also showed numerous pharmacological activity. *Homalomena aromatica* tuber are rich source of essential oils, which have been attributed for various medicinal uses and one of the major disease is Diabetes mellitus. It was also proved from the review of literature that the tuber of the plant has antioxidant and gives some of the constituent's presence by the phyto-chemical tests. Thus in this study phytochemical screening and antioxidant activity of *Homalomena aromatica* (tuber) has been performed and obtained result indicates potent antioxidant activity represented by the plant

INTRODUCTION

Northeast India, which has a diverse flora and fauna, has a greater abundance of medicinal plants. Many medicinal plants grown in this region of the country are said to be used by the locals to treat a variety of health issues. [1-3].

Homalomena aromatica Schott. (Araceae), commonly called 'Sugandhimantri' is a rhizomatous aromatic perennial herb native to Assam and neighboring states in India's sub-Himalayan region. The essential oil contained in its aromatic rhizomes is widely used in the perfumery and cosmetic industries. [4-8]. Dhup is largely made from the waste material left over after extracting essential oils. The plant also has medicinal properties in addition to its aromatic value. Traditional medicine in Northeast India employs leaves, tubers and rhizomes to treat joint pain and skin infections. [9-12]. *Homalomena aromatica* schot is an aromatic medicinal herb that is terrestrial, evergreen, annual, and belongs to the Araceae family. It can reach a height of 40-45cm and has a short, erect stem. With long petioles and sheathing below, the leaves are 20-35cm long and 15-25cm wide. Leaf blades are ovate, often cordate or sagittate. The

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flowers are unisexual lacking perianth, ovaries partially 2-4 loculed, ovules many, parietal, stigma sessile. Each ovary usually with a single, clavatest aminode, another cell short, synandria of 2-4 fused stamens, anthers attached basally, filaments short, stout, locules dehiscing extrorsely by splits. The dry tubers of *Homalomena aromatica* are known in trade as' sugandhmantri'. The tuber contains an essential oil that is primarily composed of sesquiterpenoids and is used in the production of most oriental perfumes, which are in high demand in the perfumery and cosmetic industries. [13-15]. Despite its importance, conservation of this herb is one of the major challenges confronting the region as this herb is being exploited as a forest product without conservation and cultivation measures. More than 400MT of dry tuber are collected from Barak valley of Assam and other parts of the region every year and are transported outside the state, mainly to Kannauj, Kanpur, Delhi, Kolkata and Mumbai. Indiscriminate large scale collection of *Homalomena aromatica* directly from, its natural habitat has endangered this herb. The continued unabated indiscriminate collection might lead to the extinction of this unique and valuable species from its place of origin. A comprehensive overview of phytochemical constituents of essential oils and research on antioxidant property of tuber of *Homalomena aromatica* has been highlighted in this article [16-18]. The Flowering/fruiting time of *Homalomena aromatica* is mainly in June-September. The Common names of *Homalomena aromatica* are- Gansena in Assamese, Sugandhmantri in Hindi, Gandhakochu in Bengali, Aancheeri in Mizoram, Gondhoi in Manipur [19,20]. The therapeutic potential of the essential oil from the tuber of *Homalomena aromatica* is not reported extensively but it has tremendous potential as a prospective herbal remedy for different diseases. The reported therapeutic indications of *Homalomena aromatica* are given in Table 1 [21-24]

Figure 1:- *Homalomena aromatica*

Table 1: Therapeutic indications of *Homalomena aromatica*

S. no	Plant parts	Therapeutic indication	References
1.	Rhizome	Antifungal	(Policegoudra et al 2012; Singh et al 2000; Singh et al 2002)
2.	Roots and Rhizome	Larvicidal	(Chungsamarnyart, Jiwajinda, and Jansawan 1991; Komalamisra et al 2005)
3.	Rhizome buds	Insecticidal	(Singh et al 2000)
4.	Rhizome	Insect-repellent	(Hazarika et al 2012)
5.	Rhizome	Acaricidal	(Chungsamarnyart, Ratanakreetakul and Jansawan 1994)
6.	Tuber	Antibacterial	(Laishram et al 2006)
7.	Rhizome	Hepatoprotective	(Dutta et al 2013)
8.	Rhizome and Roots	Ulcerprotective	(Chandana et al 2014)

MATERIALS AND METHOD

The major requirement used to perform the experimental work includes Methanol purchased from Vibgyor Chemical Industries, Mumbai - 400003, Maharashtra, India, DPPH obtained from sisco research laboratories pvt ltd . Dried Matured rhizome obtained from freshly collected & dried plants. Other important test kits were collected from SD. Fine chemical limited.

Collection of plant

Homalomena aromatica is commonly available in north east India, but mainly it was collected from Mirza, A small village of the district Kamrup, Assam. It was available in the form of mans cultivation process. We have collected it in the month of September. The tuber is our main part for the chemical constituent. We have also collected the plant for the authentication purpose along with the flowers available [29-32]

Shade Drying

The Tuber of the plant *Homalomena aromatica* was collected and allowed for shade drying for near about 20 days. After

complete drying of the tuber then they are allowed for grinding process into small pieces [33,34].

Fig 2:-Dried *Homalomena aromatica*

Extraction by soxhlet apparatus

The extraction was done by taking two solvent one is ethanol and the other by water. 250gm of the dried materials were taken in each soxhlet and then the extraction was done for 3 days. The percentage yield was found to b**e** 70gm alcoholic extract and 80gm of aquaeous extract [35-37]

Fig 3-Extraction and evaporation

PHYTOCHEMICAL SCREENING

For preliminary phytochemical studies, 250 gm. of powdered material was extracted with successive solvent extraction in soxhlet apparatus with ethanol-water (7:3) and water successively. Extracts were dried in water bath until it turned to a sticky mass allowing the alcohol to evaporate leaving the extract alone on the petry dish. It was then weighed. Out of the two extracts, ethanol-water extract was considered for further test for various phytoconstituents like alkaloids, glycosides, steroids, saponins etc. with ethanol-water extract by usual methods prescribed in standard text [38-40].

Following test like **Detection of alkaloids** (Mayer's test, Dragendorff's test, Wagner's test), **Detection of carbohydrates** (Molisch's test, Fehling's test, Barfoed's test, Benedict's test), **Detection of proteins and amino acids** (Biuret test, Millon's test, Xanthoprotien test), **Detection of glycosides {**Keller-killiani test (test for deoxy sugars), Borntrager's test (anthraquinone glycoside)}, Detection of saponin glycoside, **Detection of Tannins & phenols (**froth formation test), **Detection of Tannins & phenols(**Ferric chloride test,Lead actetate test, Gelatin test, Aqueous bromine test), **Detection of flavonoids (**Alkaline reagent test), **Detection of fixed oil (** Spot test) were performed [41-44].

Evaluation of antioxidant activity (*In Vitro*) by DPPH radical scavenging

The free radical scavenging activity was calculated by 1,1-Diphenyl-2-picrylhydrazyl (DPPH) method [46-48]. DPPH solution of 0.1 mM was prepared freshly in methanol and kept away from light for 30 min and then the initial absorbance was measured at 517 nm using UV-Vis Spectrophotometer. Final concentration of standard ascorbic acid and plant extracts were made at different concentrations (20µg, 40µg, 60µg, 80µg and 100 µg) were taken and the volumes were adjusted to 1ml with methanol for methanolic sample and water for water sample. The final volume to be assayed was filled by adding 1ml of methanolic DPPH solution to 1ml of different concentrations of plant extract in an eppendorf tube of 2ml [49].

Three separate tests were performed for the sample. The tubes were allowed to incubate in dark for 30min at 27ºC. Both methanol and water was used as blank for methanolic and water samples and the experiment was expressed as the inhibition percentage (%) of free radical by the sample and was calculated

using the formula follows: Where, Abs control is the absorbance of DPPH + methanol Abs sample is the absorbance of DPPH radical + sample (i.e., extract or standard) [50,51].

$$Radical\ scavenging\ (\%) = \frac{Abs_{control} - Abs_{sample}}{Abs_{control}} \times 100$$

The therapeutic potential of the essential oil from the tuber of *H. aromatica* is not reported extensively but it has tremendous potential as a prospective herbal remedy for different diseases. The reported therapeutic indications of H. aromatica are given in Table 1 [52,53]

RESULTS AND DISCUSSION

RESULTS

The extracts were subjected to phytochemical analysis and the results are represented in the tables below

S NO	PHYTOCHEMICAL PRESENCE	TEST	RESULTS
1	Carbohydrate	Mayer's test	Positive
		Wagner's test	Positive
		Dragendroffs test	Positive
2	Alkaloid	Molish's test	Positive
		Fehling's test	Positive
		Benedict test	Positive
		Barfoed's test	Positive
3	Saponins	Detection of saponins	Positive
4	Glycosides	Lead acetate test	Positive
		Keller-killiani test	positive
5	Phenolic	Ferric chloride test	Positive
		Gelatin test	Positive
6	Protein and amino acid	Millon's test	Negative
		Biuret test	Negative
		Ninhydrin test	Negative
		Legals test	Negative
7	Flavonoid		Positive
8	Fixed oil and fats	Spot test	Positive
		Saponification test	Positive

DETERMINATION OF ANTIOXIDANT ACTIVITY

An antioxidant can be broadly defined as any substance that delays or inhibits oxidative damage to a target molecules and the main characteristic is to trap free radicals.

We have done the antioxidant activity by taking the extract which was screened by free radical scavenging activity (DPPH) [54,55].

Table-12:-

SNo	Concentration (µg/ml)	Inhibition %
1	20	31.39 ±0.91
2	40	44.13 ±0.93
3	60	56.21 ±0.25
4	80	62.3 ±0.32
5	100	71.02 ±0.11

All data were expressed in± SEM

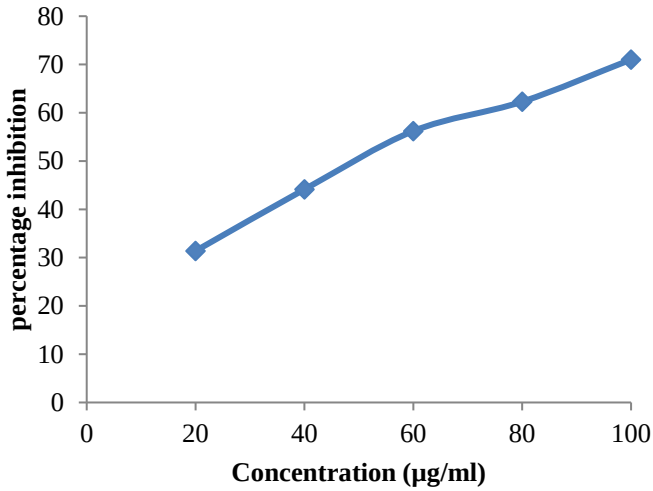

Table-13:-DETERMINATION OF IC50

SL NO	EXTRACT	IC50(µg/ml)
1	Methanol	61.65±01.12
2	Ascorbic acid	11.36±1.02

DISCUSSION

The following research work was carried out for the standardization of the tuber of *Homalomena aromatica* along with the evaluation of its antioxidant property. Percentage of extractives in different solvent helped us to determine the quantity and nature of active phytoconstituents in the extract. In the test we found the Alcoholic extract to be more (80gm) then the water extract (60gm). The water soluble extractive value indicates the presence of sugar, acids and inorganic compounds

and alcohol soluble extractive values indicates the presence of polar constituents like phenols, steroids, glycosides and flavonoids. The extracts were subjected to preliminary phytochemical analysis to identify the presence of Phytoconstituent such as alkaloids, phenols, glycosides, saponins, flavonoids, carbohydrates, proteins and fixed oil.

The presence of flavanoides in the hydro-alcoholic(ethanolic) extract of the tuber of the plant *Homalomena aromatica* have been reported which are known to be as natural antioxidants. So, the extract was planned to be evaluated for *in-vitro* antioxidant activity using DPPH radical scavenging model. The study was carried out by taking ascorbic acid as the standard antioxidant which is also a natural antioxidant. The result of antioxidant activity was expressed in terms of % inhibition of generated free radicals with respect to various concentrations of the extract. Concentration dependent effects were observed i.e., higher concentrations were found to exhibit higher % of inhibition. The graphs were constructed by taking % inhibition along the X-axis and various concentrations were taken along Y-axis. The IC_{50} value (50% inhibition) of the tuber extract and the standard ascorbic acid were determined. The observed IC_{50} value of the tuber of *Homalomena aromatica* with reference to the standard ascorbic acid was found to be i.e., IC_{50} value of tuber extract: 61.65 µg/ml and IC_{50} valueof standard: 11.36 µg/ml.

CONCLUSION

An attempt has been made to evaluate the phytochemical parameters and antioxidant activity of the tuber of *Homalomena aromatica* and we have found that it has the effective antioxidant property. The preliminary phytochemical activity study indicate the presence of alkaloids, glycosides, saponins, flavonoides, carbohydrates, proteins, fixed oil and phenolic compounds as major class of phytochemical.

FINANCIAL ASSISTANCE

Nil

CONFLICT OF INTEREST

The authors declare no conflict of interest.

REFERENCES

[1] Kehie M, Kehie P, Pfoze N L. Phytochemical and ethnopharmacological overview of endangered *Homalomena aromatica* Schott: An aromatic medicinal herb of Northeast India. *Indian Journal of Natural Products and Resources (IJNPR)*, 8(1), 18-31 (2017)

[2] Policegoudra R S, Goswami S , Aradhya S M , Chatterjee S, Datta S , Sivaswamy R , Chattopadhyay P , Singh L. Bioactive constituents of *Homalomena aromatica* essential oil and its antifungal activity against dermatophytes and yeasts .*Journal de Mycologie Medicale*, 22(1),83-87 (2011)

[3] Raomai S**,** Kumari S, Tandon P. In vitro propagation of *Homalomena aromatica* Schott An endangered aromatic medicinal herb of Northeast India. *Physiol Mol Biol Plants, 19*(2), 297-300 (2013)

[4] Auwal M S, Saka S, Mairiga I A, Sanda K A, Shuaibu A, Ibrahim A. Preliminary phytochemical and elemental analysis of aqueous and fractionated pod extracts of *Acacia nilotica* (Thorn mimosa).*Vet Res Forum*,5(2), 95–100 (2014)

[5] Ramamurthy V, Sathiyadevi M. Preliminary Phytochemical Screening of Methanol Extract of *Indigotera trita Linn*. *Journal of J Plant Biochemistry & Physiology*, 5(2) (2017)

[6] Blois M S. Antioxidant determinations by the use of a stable free radical. *Nature*, 181, 1199-1200 (1958)

[7] Roy SJ , Baruah PS, Lahkar L, Gurung L, Saikia D , Tanti B. Phytochemical analysis and antioxidant activities of *Homalomena aromatica* Schott . *Journal of Pharmacognosy and Phytochemistry*, 8(1), 1379-1385(2019)

[8] Goswami AK, Banu ZW, Sharma HK. CNS effects of *Homalomena aromatica* based on linalool content: A review. *Current trends in pharmaceutical research*, 3(2), 20-38(2016)

[9] Alinejad B, Ghorbani A, Sadeghnia HR. Effects of combinations of curcumin, linalool, rutin, safranal and thymoquinone on glucose/serum deprivation induced cell death. *Avicenna J Phytomed*, 3(4), 321-328 (2016)

[10] Almeida RN, Navarro DS, Barbosa-Filho JM. Plants with central analgesic activity. *Phytomedicine*, 8(4), 310–322 (2005)

[11] Barua CC, Talukdar A, Phukan B, Hazarika S, Barua AG, Baishya G. Phytochemical screening and in-vitro antioxidant activity of ethanolic extract of *Homalomena aromatica* (Araceae) root. *Der Pharma Lett*, 6(1), 128-138 (2014)

[12] Bassil N, Grossberg GT. Novel regimens and delivery systems in the pharmacological treatment of Alzheimer's disease. *CNS Drugs*, 23(4), 293-307(2009)

[13] Batista PA, Werner MF, Oliveira EC, Burgos L, Pereira P, Brum LF, Santos AR. Evidence for the involvement of ionotropic glutamatergic receptors on the antinociceptive effect of (-)-linalool in mice. *Neurosci Lett*, 440(3), 299–30 (2008)

[14] Bickers D, Calow P, Greim H, Hanifin JM, Rogers AE, Saurat JH, Sipes IG, Smith RL, Tagami HA. A toxicologic and dermatologic assessment of linalool and related esters when used as fragrance ingredients. *Food Chem Toxicol*, 41(7), 919–942 (2003)

[15] Buchbauer G, Jirovetz L, Jager W, Dietrich H, Plank C. Aromatherapy:Evidence for sedative effects of the essential oil of lavender after inhalation , *Z Naturforsch C*, 46,1067–1072 (1991)

[16] Carlini EA. Plants and the central nervous system. *Pharmacol Biochem Behav*, 75(3), 501–512 (2003)

[17] Celik S, Ozkaya A. Effects of intraperitoneally administered lipoic acid, vitamin E, and linalool on the level of total lipid and fatty acids in guinea pig brain with oxidative stress induced by H_2O_2. *J Biochem Mol Biol*, 35(6), 547-552 (2002)

[18] Chadha A, Madyastha KM. Metabolism of geraniol and linalool in the rat and effects on liver and lung microsomal enzymes. *Xenobiotica*, 14,365–374 (1984)

[19] Chandana CB, Anindita T, Acheenta GB, Debesh CP, Iswar CB. Ulcer protective activity of ethanolic extract of *Homalomena aromatica* (Spreng.) Schott. (Araceae) root. *Adv Tech Bio Med*, 117 (2014)

[20] ChildersSR. Opioid receptor-coupled second messenger systems. *Life Sci*, 48(21), 1991– 2003 (1991)

[21] Chungsamarnyart N, Jiwajinda S, Jansawan W. Larvicidal effect of plant crude-extracts on the tropical cattle tick (Boophilus microplus). *Agric Nat Resoure*, 25, 80-89 (1991)

[22] Chungsamarnyart N, Ratanakreetakul C, Jansawan W. Acaricidal activity of the combination of plant crude extracts to tropical cattle ticks. *Agric Nat Resoure*, 28(4), 649-660 (1994)

[23] Cioanca O, Hritcu L, Mihasan M, Hancianu M. Cognitive-enhancing and antioxidant activities of inhaled coriander volatile oil in amyloid β (1–42) rat model of Alzheimer's disease. *Physiol Behav*, 120, 193–202(2013)

[24] De-Almeida ER, Rafael KR, Couto GB, Ishigami AB. Anxiolytic and anticonvulsant effects on mice of flavonoids, linalool, and α-tocopherol present in the extract of leaves of Cissus sicyoides L. (Vitaceae). *J Biomed Biotechnol*, doi:10.1155/2009/274740 (2009)

[25] Dinda B, Chowdhury DR, Mohanta BC. Naturally occurring iridoids,secoiridoids and their bioactivity: An updated review, part 3. *Chem Pharm Bull*, 57(8), 765-796 (2009)

[26] Dudhgaonkar SP, Kumar D, Naik A, Devi AR, Bawankule DU, Tandan SK. Interaction of inducible nitric oxide synthase and cyclooxygenase-2 inhibitors in formalin-induced nociception in mice. *Eur J Pharmacol*, 492(2-3), 117– 122 (2004)

[27] Dutta B, Lahkar M, Augustine BB, Lihite RJ. Hepatoprotective activity of Tamarind indica and *Homalomena aromatica* in rats. *Int J Pharm Pharm Sci*, 5(2), 436-438 (2013)

[28] Elisabestky E, Marschner J, Souza DO. Effects of linalool on glutamatergic system in the rat cerebral cortex. *Neurochem Res*, 20, 461–465 (1995)

[29] Elisabetsky E, Brum LF, Souza DO. Anticonvulsant properties of linalool in glutamate-related seizure models. *Phytomedicine*, 6(2), 107-113 (1999)

[30] Elisabetsky E, Coelho De Souza GP, Dos Santos MAC, Siqueira IR, Amador TA, Nunes DS. Sedative properties of Linalool. *Fitoterapia*, 115(5), 407-414 (1995)

[31] García MD, Quílez AM, Sáenz MT, Martínez-Domínguez ME , De-la-puerta R. Anti-inflammatory activity of Agave intermixta Trel. and Cissus sicyoides L.,species used in the Caribbean traditional medicine. *J Ethnopharmacol*, 71(3), 395–40 (2000)

[32] Gilani AH, Aziz N, Khan MA, Shaheen F, Jabeen Q, Siddiqui BS , Herzig JW. Ethnopharmacological evaluation of the anti-convulsant, sedative and anti-spasmodic activities of Lavandula stoechas L. *J Ethnopharmacol*, 71 (1-2):161-167.2000

[33] Giorgi O, Orlandi M, Geic M, Corda MG. MK-801 prevents the decrease in 35S-TBPS binding in the rat cerebral cortex induced by pentylenetetrazol kindling. *Brain Res Bull*, 27(6), 835-837(1991)

[34] Griffiths M, Neal JW, Gasque P. Innate immunity and protective neuroinflammation: new emphasis on the role of neuroimmune regulatory proteins. *Int Rev Neurobiol*, 82,29–55 (2007)

[35] Hajhashemi V, Ghannadi A, Sharif B. Anti-inflammatory and analgesic properties of the leaf extracts and essential

oil of Lavandula angustifolia Mill. *J Ethnopharmaco*l, 89(1), 67–71(2003)

[36] Hardy M, Kirk-Smith MD, Stretch DD. Replacement of drug treatment for insomnia by ambient odour. *Lancet*, 346(8976), 701(1995)

[37] Hazarika S, Dhiman S, Rabha B, Bhola RK , Singh L . Repellent activity of some essential oils against Simulium species in India. *J Insect Sci*, 12, doi:10.1673/031.012.0501 (2012)

[38] Heneka MT, Kummer MP, Latz E. Innate immune activation in neurodegenerative disease. *Nat Rev Immunol*, 14,463–477 (2014)

[39] Ito Y, Sugimoto A, Kakuda T, Kubota K. Identification of potent odorants in Chinese jasmine green tea scented with flowers of Jasminum sambac . *J Agric Food Chem*, 50(17), 4878–4884 (2002)

[40] Jager W, Buchbauer G, Jirovetz L, Fritzer M. Percutaneous absorption of lavender oil from a massage oil. *J Soc Cosmet Chem*, 43, 49–54 (1992)

[41] Kain ZN, Sevarino F, Pincus S, Alexander GM, Wang SM, Ayoub C, Kosarussavadi B . Attenuation of the preoperative stress response with midazolam: effects on postoperative outcomes. *Anesthesiology*, 93(1), 141-147 (2000)

[42] Kainer KA, Duriea ML. Tapping women's knowledge: Plant resource use in extractive reserves, Acre, Brazil. *Econ Bot*, 46(4), 408-425(1992)

[43] Kang JH, Ryoo NY, Shin DW, Trojanowski JQ , Shaw LM. Role of cerebrospinal fluid biomarkers in clinical trials for Alzheimer's disease modifying therapies. *Korean J Physiol Pharmacol*, 18(6), 447-456 (2014)

[44] Katsuse O, Iseki E, Kosaka K. Immunohistochemical study of the expression of cytokines and nitric oxide synthases in brains of patients with dementia with lewy bodies. *Neuropathology*, 23(1), 9-15 (2003)

[45] Kim KY, Lee HS, Min SS, Seol GH. Neuroprotective effect of (-)-linalool against sodium nitroprusside-induced cytotoxicity. *Med Chem*, 5, 178-182 (2015)

[46] Komalamisra N, Trongtokit Y, Rongsriyam Y, Apiwathnasorn C. Screening for larvicidal activity in some Thai plants against four mosquito vector species. *Southeast Asian J Trop Med Public Health*, 36(6), 1412-1422 (2005)

[47] Kuroda K, Inoue N, Ito Y, Kubota K, Sugimoto A, Kakuda T , Fushiki T .Sedative effects of the jasmine tea odor and (R)-(-)-linalool, one of its major odor components, on autonomic nerve activity and mood states. *Eur J Appl Physiol*, 95(2-3), 107–114 (2005)

[48] Laishram KS, Nath DR, Bailung B, Baruah I. In-viro antibacterial activity of essential oil from rhizome of *Homalomena aromatica* against pathogenic bacteria. *J CellTissue Res*, 6(2), 849-851 (2006)

[49] Li Y, Lv O, Zhou F, Li Q, Wu Z, Zheng Y. Linalool Inhibits LPS-induced inflammation in BV2 microglia cells by activating Nrf2. *Neurochem Res*, 40(7), 15-20 (2015)

[50] Linck VM, DaSilva AL, Figueiro M, Caram EB, Moreno PRH , Elisabetsky E. Effects of inhaled linalool in anxiety, social interaction and aggressive behavior in mice. *Phytomedicine*, 17(8-9), 679–683 (2010)

[51] Lipton SA, Rosemberg PA. Excitatory amino acids as a final common pathway for neurologic disorders. *N Engl J Med*, 330(90), 613-622 (1994)

[52] Lushchak OV, Lushchak VI. Sodium nitroprusside induces mild oxidative stress in Saccharomyces cerevisiae. *Redox Rep*, 13(4), 144-152 (2008)

[53] Lyons CR. The role of nitric oxide in inflammation. *Adv Immunol*, 60, 323– 371 (1995)

[54] Majumdar K, Datta BK. A study on ethnomedicinal usage of plants among the folklore herbalists and Tripuri medical practitioners: Part-II. *Nat Prod Radiance*, 6(1), 66-73 (2007)

[55] Marcinkiewicz J, Grabowska A, Chain B. Nitric oxide up-regulates the release of inflammatory mediators by mouse macrophages. *Eur J Pharmacol*, 25(4), 947–951 (1995)