Gac Sanit. 2021;35(S2):S459–S462

Essential oil as a new tool for larvicidal *Aedes aegypti*: A systematic review

Budiman[a,b,*], Hasanuddin Ishak[b], Stang[b], Erniwati Ibrahim[b], Anwar Daud[b], Ridwan Amiruddin[b]

[a] *Faculty of Public Health, Muhammadiyah University, Palu, Indonesia*
[b] *Faculty of Public Health, Hasanuddin University, Makassar, Indonesia*

ARTICLE INFO

Article history:
Received 28 June 2021
Accepted 30 July 2021

Keywords:
Aedes aegypti
Essential oil
Larvicidal
Mosquito
Plants

ABSTRACT

Objective: The study aimed to describe the effectiveness of essential oil plants for *Aedes aegypti* mosquito vector control.
Methods: This systematic review selection process following with 2015 Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) Guideline. The source of the articles from databases international journal were Scopus, Pubmed, Scinapse and Google Scholar.
Result: Natural control management with essential oil is the way of alternative for larvicidal mosquito control especially *A. aegypti*. The essential oil for many plants can use for larvicidal against *A. aegypti* as *Piper batle* L., *Tinospora rhumpii, Azadiractha indica, Persea americana, Piper aduncum, Leucas aspera, Eucaliptus camaldulensis, Ottonia anisum, Salvia Plebeian, Lantana camara*, and *Syzygium aromaticum* with 100% mortality larvae *A. aegypti* at 48 h.
Conclusions: The vector borne diseases must be used to integrate vector management control with essential oils plants.

Introduction

Diseases transmitted by vectors, in particular dengue, are a diseases that threatens public health worldwide.[1] The global burden of dengue fever cases is 96 million cases per year, with a death total of 9.110 per year.[2,3]

Nowadays, dengue control is often carried out by chemical control which will continuously have adverse effects such as the death of non-target organisms, pollution of the environment and endangering public health. In addition, this method also costs a lot of money and can cause resistance to mosquitoes.[4,5]

Biological control can be an alternative to the control of vector mosquitoes by reducing the population of vector mosquitoes using natural materials. The alternative to vector control use essential oils or plants oil and extracts has been encouraged by many researchers.[5] Plant essential oils can interfere the respiratory, digestive, metabolic, behavioral and psychological systems of insects, especially mosquitoes.[6]

Therefore, a systematic review of the literature based on a review is needed that will provide insight into the efficacy of plant essential oils as a novel means of controlling the *Aedes aegypti* vector.

Methods

Study selection

This systematic review selection procees following with 2015 PRISMA/Preferred Reporting Items for Systematic Reviews and Meta-Analyses Guideline.[7] Literature review sources come from online searches of national and international reputable journal databases and e-books. The journal is indexed by Scopus, Pubmed, Scinapse and Google Scholar databases. Literature collected is based on topics raised in the last 10 years of publication between 2009 until 2019. Furthermore, all articles that have been collected are entered into the mendeley system. The search used keywords

- Biolarvicidal* OR larvicidal* OR larvacidal*
- Essential Oil* OR Extract* OR Plant Oil*
- *Aedes aegypti**
- Mosquito*

Inclusion and exclusion criteria

The search criteria in the database, are those which (a) focused on essential oil; (b) Larvicidal; (c) Experimental Study; (d) were published during the last ten years (2009 to 2019); (e) English-language articles; (f) Open access. Exclusion criteria were (1) Review/editorial, (2) Conference proceedings, (3) Study Protocol.

Data extraction

This systematic review using the 2015 PRISMA guideline to select the articles that have been submitted. After reading the title and abstract, articles that do not match the theme will be excluded.

Peer-review under responsibility of the scientific committee of the 3rd International Nursing, Health Science Students & Health Care Professionals Conference. Full-text and the content of it is under responsibility of authors of the article.

* Corresponding author.
E-mail addresses: budiman19k@student.unhas.ac.id, pmc@agri.unhas.ac.id (Budiman).

https://doi.org/10.1016/j.gaceta.2021.10.074

Table 1
Summary of selected studies essential oil for larvicidal.

No.	Author, year, country	Object	Method, larvacidal assay	Assessment quality (0–8 points)	Funding
1	Riesna Martianasari and Penny Humaidah Hamid, 2019, Indonesia[15]	Egg, Larvae and Adult	WHO Guideline/Gas chromatography–mass spectrometry (GC–MS)	High (8)	Potential use of *Piper betle* L. essential oil is at the concentration of 500 ppm (100% mortality in 1 h)
2	Pedro M et al., 2014, Philipina[16]	Third stage larvae	WHO Guideline/Gas chromatography–mass spectrometry (GC–MS)	High (8)	Larvicidal activity to *Aedes aegypti* mosquito larvae of 60 mg/ml (48 h *Jatropa curcas* 61.67%, *Citrus grandis* 83.3%, *Tinospora rhumpii* 93.3%)
3	Muhammad Uzair et al., 2015, Pakistan[17]	Third and fourth intsar larvae	WHO Guideline/Gas chromatography–mass spectrometry (GC–MS)	High (7)	*Azadiractha indica* oil was considered best 100% mortality after 24 h at 3% and 4% concentration.
4	Laura Scalvenzi et al., 2019, Italia[18]	Third and fourth intsar larvae	WHO Guideline/Gas chromatography–mass spectrometry (GC–MS)	High (7)	After 24 h, percentage mortality franged from 2.7 (50 μg/mL) to 100% for *Piper aduncum*; from 2.2 (250 μg/mL) to 100% for *Ocimum camphechianum*; and from 2,9 (250 μg/mL) to 100% for *Ocotea quixos*
5	D. Elumalai, P. et al., 2017, India[19]	Fourth intsar larvae	WHO Guideline/Gas chromatography–mass spectrometry (GC–MS)	High (8)	After 24 h, methanol extract of Leucas aspera showed mortality against *A. aegypti* untl 100% at 80 ppm and more potent
6	Sen-Sung Cheng et al, 2009, Taiwan[20]	Fourth intsar larvae	WHO Guideline/Gas chromatography–mass spectrometry (GC–MS)	High (7)	*Eucalyptus camaldulensis* leaf essential oil against *A. aegypti* in concentration 100% larval mortality at 100 μg/ml and concentration 200 μg/ml *Eucalyptus urophylla* at 24 h
7	André M. Marques et al., 2017, Brazil[21]	Third stage larvae	WHO Guideline/Gas chromatography–mass spectrometry (GC–MS)	High (7)	Concentration tested until 200 μg/ml (30 μg/ml), the L3 larval mortality was 100%, 24 h after treatment
8	Ivoke, N. and Odii, E. C, 2010, Nigeria[22]	Third stage larvae	WHO Guideline/Gas chromatography–mass spectrometry (GC–MS)	High (7)	Essential oil of Lantana camara against early third stage larvae of *A. aegypti*, 100% mortality was recorded at 50 mg/l concentration and leveled off thereafter
9	Nwankwo, E. N. et al., 2011, Nigeria[23]	Third stage larvae	WHO Guideline/Gas chromatography–mass spectrometry (GC–MS)	High (7)	Mortality increased with increasing concentration. 95% larval mortality against *A. aegypti* in 12 h with concentration 95 μg/ml
10	Alzeir Machado Rodrigues et al., 2018, Brazil[24]	Third and fourth instars of *A. aegypti*	WHO Guideline/Gas chromatography–mass spectrometry (GC–MS)	High (7)	Essential oil of *Syzigium aromaticum* were 32.7 ppm and *Croton nepetaefolius* 81.7 ppm after 24 h was found 50% larval mortality (LC50)
11	Kehinde Adenike Fayemiwo et al., 2014, Nigeria[25]	Third stage larvae	WHO Guideline/Gas chromatography–mass spectrometry (GC–MS)	High (8)	After 24 h was found over 85% larval mortality. *Syzigium aromaticum* were more susceptible against *A. aegypti* LC50 at 92,56 mg/ml and pinus sylvestris 128 mg/ml
12	Adriana Faraco et al., 2016, Brazil[26]	Third stage larvae	WHO Guideline/Gas chromatography–mass spectrometry (GC–MS)	High (7)	All tested species was found laricidal effects in *Syzigium aromaticum* and *Citrus sinensis* but not recommended for combination with temephos
13	Eunice da S. Medeiros et al., 2012, Brazil[12]	Third stage larvae	WHO Guideline/Gas chromatography–mass spectrometry (GC–MS)	High (7)	For *A. aegypti* larvae, the highest mortality rate occurred within 24 h in the aqueous extract. Eugenol exhibited the highest motality rate on *A. aegypti* larvae at 48 h

Then the articles will be read in full text to find out the year, object, method larvicidal assay and research fundings. After collection various literature, it is then discussed with various relevant and competitive experts to be made together in a good literature review.

Quality assessment

To asses quality assessment and studies reviewed the articles was used STROBE/Strengthening the Reporting of Observational Studies in Epidemiology checklist.[8] The STROBE checklist based on the 22 item but in this study used 8 quality-appraisal criteria: Objectives, Study design, Setting, Data source/measurement, Outcome data, Limitation, Interpretation and Funding (Table 1). Eligible articles are the articles that obtain the highest score in the evaluation of the quality of the article were rated as score ≤3 (poor); score 4–6 (medium); and score ≥7 (high).[9]

Result

The total of journal is 7112 articles were referred from the four data bases. After articles removing are 747 articles, articles abstract is reviewed after reading titles (not mosquito) is 157 articles. At last, 36 articles full-text reviewed and excluded is 20 articles. As many as 3 articles included after reading reference from manual search. Finally a total of 13 articles (Fig. 1).

Various efforts have been made to prevent the emergence of mosquito resistance to certain chemicals.[10,11] Therefore, a more environmentally friendly, effective, efficient and safe way to control health is needed. Biological control can be an alternative in the fight

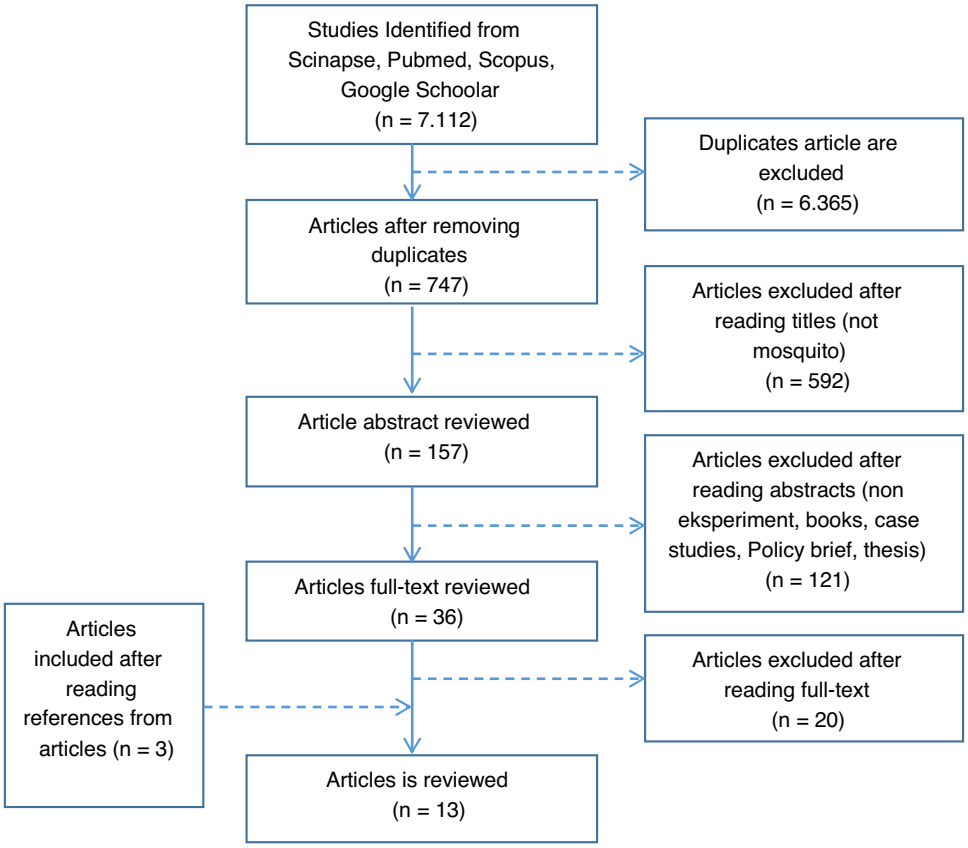

Fig. 1. Flow chart articles based on 2015 PRISMA guideline.[7]

against vector mosquitoes by reducing the populations of vector mosquitoes and by using natural materials.[5]

One of the alternatives that can be used in mosquito vector control began to be encouraged by researchers. Essential oils from plants can damage with respiratory, digestive, metabolic, behavioral and psychological of insects especially mosquitoes.[6,12]

The essential oil for many plants can use for larvicidal against *A. aegypti* as *Piper batle* L., *Tinospora rhumpii*, *Azadiractha indica*, *Persea americana*, *Piper aduncum*, *Leucas aspera*, *Eucaliptus camaldulensis*, *Ottonia anisum*, *Salvia Plebeian*, *Lantana camara*, and *Syzygium aromaticum* with 100% mortality larvae *A. aegypti* at 48 h.

Discussion

Various researches from experts regarding the ability of essential oils to kill mosquito vectors have encouraged further exploration of the possibility of using essential oils from certain plants as an alternative step in controlling diseases transmitted by mosquito vectors. The chemical compound content of essential oils that have been studied from various types of plants shows that locally sourced plant chemical content is more effective than previous research reports but with slight variations. Factors that cause different variations are usually associated with the differences and similarities in the chemotype of each species observed. In addition, the influence of environmental differences also affects the development and physiology of these species.[12,13]

The results showed that essential oils from various plants have toxic substances for mosquito larvae so that they can kill mosquito larvae with an average mortality rate of more than 85% for 24 h and a mortality rate of 100% mosquito larvae for 48 h although there is no significant difference in giving concentration levels of the plant's essential oil. Many plants have been believed to have a high biological ability to fight pathogenic microorganisms and insect pests. The difference in the level of essential oil toxicity is probably caused by differences in the variation in the content of chemical compounds that will determine the plant's ability to kill mosquito larvae.[13,14]

The content of the main chemical compounds of essential oils plant has been widely used as a formula in the management of pest and insect pathogen control because it is known to have high toxic and antimicrobial and insecticidal properties. The difference in resistance levels and insecticide susceptibility of various insect vectors, especially mosquitoes, can be caused by various factors including differences in physiological and biochemical processes of the insects themselves.[12,14]

Conclusion

This literature review concludes that essential oils from several plants have the potential to kill mosquito vectors so that this local essential oil can be used as a new way of managing mosquito vector control, especially in dengue hemorrhagic fever endemic areas and remote areas that are difficult to access by health facilities.[12–14]

Conflicts of interest

The authors declare no conflict of interest.

Acknowledgments

This literature review is one of the requirements in taking doctoral studies in Faculty of Public Health Hasanuddin University Indonesia. First author was presented at International Conference on Safety and Public Health (ICOS-PH, 2020) "Global Collaboration for Safety and Public Health" Makassar, Sept 3rd – 4th 2020.

References

1. WHO. Global Vector Control Response. Geneva; 2020. p. 64.
2. Bhatt S, Gething PW, Brady OJ, et al. The global distribution and burden of dengue. The Global Distribution and Burden of Dengue. Nature. 2013;496:504–7.
3. Vos T, Allen C, Arora M, et al. Global, regional, and national incidence, prevalence, and years lived with disability for 310 diseases and injuries, 1990–2015: a systematic analysis for the Global Burden of Disease Study 2015. Lancet. 2016;388(10053):1545–602.
4. Olatunbosun-Oduola A, Abba E, Adelaja O, et al. Widespread report of multiple insecticide resistance in *Anopheles gambiae* s.l. mosquitoes in eight communities in southern Gombe, north-eastern Nigeria. J Arthropod Borne Dis. 2019;13:50–61.
5. Roiz D, Wilson AL, Scott TW, et al. Integrated *Aedes* management for the control of Aedes-borne diseases. PLoS Negl Trop Dis. 2018;12:1–21.
6. Maia MF, Moore SJ. Plant-based insect repellents: a review of their efficacy, development and testing. Malar J. 2011;10 Suppl. 1:1–15.
7. Moher D, Liberati A, Tetzlaff J, et al. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. PLoS Med. 2009;6.
8. Vandenbroucke JP, von Elm E, Altman DG, et al. Strengthening the Reporting of Observational Studies in Epidemiology (STROBE): explanation and elaboration. Int J Surg. 2014;12:1500–24.
9. Tahangnacca M, Amiruddin R, Ansariadi, et al. Model of stunting determinants: a systematic review. Enferm Clin. 2020;30:241–5.
10. Echeverría J, Albuquerque R. Nanoemulsions of essential oils: new tool for control of vector-borne diseases and in vitro effects on some parasitic agents. Medicines. 2019;6:42.
11. Luna EC, Luna IS, Scotti L, et al. Active essential oils and their components in use against neglected diseases and arboviruses. Oxid Med Cell Longev. 2019; 2019.
12. Medeiros ES, Rodrigues IB, Litaiff-abreu E, et al. Larvicidal activity of clove (*Eugenia caryophyllata*) extracts and eugenol against *Aedes aegypti* and *Anopheles darlingi*. Afr J Biotechnol. 2013;12:836–40.
13. Cortés-Rojas DF, de Souza CRF, Oliveira WP. Clove (*Syzygium aromaticum*): a precious spice. Asian Pac J Trop Biomed. 2014;4:90–6.
14. Elzayyat E, Elleboudy N, Moustafa A, et al. Insecticidal, oxidative, and genotoxic activities of *Syzygium aromaticum* and *Eucalyptus globulus* on *Culex pipiens* adults and larvae. Turkiye Parazitolojii Derg. 2018;42:213–22.
15. Martianasari R, Hamid PH. Larvicidal, adulticidal, and oviposition-deterrent activity of *Piper betle* L. essential oil to *Aedes aegypti*. Vet World. 2019;12:367–71.
16. Nunes F, Guimarães L, Lacerda D, et al. Larvicidal activity of *Agave sisalana* against *Aedes aegypti* mosquito, the dengue vector. BMC Proc. 2014;8(S4):23–32.
17. Mukhtar MU, Mushtaq S, Arslan A, et al. Laboratory study on larvicidal activity of different plant extracts against *Aedes aegypti*. Lab study Larvicidal Act Differ plant Extr against *Aedes aegypti*. 2015;2:127–30.
18. Scalvenzi L, Radice M, Toma L, et al. Larvicidal activity ncum essential oils against *Aedes aegypti*. Parasite. 2019;26.
19. Elumalai D, Hemalatha P, Kaleena PK. Larvicidal activity and GC–MS analysis of *Leucas aspera* against *Aedes aegypti Anopheles stephensi* and *Culex quinquefasciatus*. J Saudi Soc Agric Sci. 2017;16:306–13.
20. Cheng SS, Huang CG, Chen YJ, et al. Chemical compositions and larvicidal activities of leaf essential oils from two eucalyptus species. Bioresour Technol. 2009;100:452–6.
21. Marques AM, Velozo LS, Carvalho MA, et al. Larvicidal activity of *Ottonia anisum* metabolites against *Aedes aegypti*: a potential natural alternative source for mosquito vector control in Brazil. J Vector Borne Dis. 2017;54:61–8.
22. Ivoke N, Odii E. Larvicidal effect of essential oil from leaves of *Lantana camara* (Verbenaceae) against *Aedes aegypti* (Diptera: Culicidae). Bio-Research. 2010;8:646–50.
23. Nwankwo E, Okonkwo NJ, Ozumba NA, et al. Comparative studies on the larvicidal action of Novaluron (Mosquiron® 100EC) and Moringa Oliefera (LAM) seed oil against *Aedes aegypti* (Diptera: Culicidae) larvae. Afr Res Rev. 2011;5:424–37.
24. Rodrigues AM, Sampaio CDG, Souza JSND, et al. Different susceptibilities of *Aedes aegypti* and *Aedes albopictus* larvae to plant-derived products. Rev Soc Bras Med Trop. 2019;52:e20180197.
25. Fayemiwo KA, Adeleke MA, Okoro OP, et al. Larvicidal efficacies and chemical composition of essential oils of *Pinus sylvestris* and *Syzygium aromaticum* against mosquitoes. Asian Pac J Trop Biomed. 2014;4:30–4.
26. de Oliveira Araujo AF, Ribeiro-Paes JT, de D.J.T., et al. Larvicidal activity of *Syzygium aromaticum* (L.) Merr and *Citrus sinensis* (L.) Osbeck essential oils and their antagonistic effects with temephos in resistant populations of *Aedes aegypti*. Mem Inst Oswaldo Cruz. 2016;111:443–9.