Annual Research & Review in Biology

Volume 38, Issue 12, Page 45-50, 2023; Article no.ARRB.86101
ISSN: 2347-565X, NLM ID: 101632869

Comparative Studies of Repellent Activity of 5 Essential Oils Extracted from Plants in Jos North Plateau State against Mosquito Bites

Idoko Ogbe [a*], Jennifer Ene Idoko [b], Onyike Onyinyechi Gift [a], Hillary Ehgomare Okan [c] and Elizabeth Ogbe [d]

[a] University of Jos, Nigeria.
[b] Federal University of Health Sciences, Otukpo, Nigeria.
[c] NVRI VOM, Nigeria.
[d] University of Agriculture Makurdi, Benue State, Nigeria.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/ARRB/2023/v38i1230621

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/86101

Original Research Article

Received: 25/10/2023
Accepted: 29/12/2023
Published: 30/12/2023

ABSTRACT

The ability of the mosquitoes to repel five essential oils from plants at four different concentrations was evaluated against the mosquito *Aedes aegypti* under certain conditions in the laboratory using human subjects. 0.2 mL of the oil was applied per 25 cm^2 of exposed skin of the volunteer's forearm. When the tested oils were applied and evaluated at a 5%, 10%, 15% concentration, the mosquito bites were not prevented for as long as 1 hour. However, the undiluted oils of Ginger, Garlic, and Lemon grass were the most efficient and shows 1 h of complete repellent. The initial results indicate that four concentrations (5%, 10%, 15% of Ginger, Lemon grass and Turmeric were used) for repellency tests against *Anopheles dirus*. The undiluted oil indicated the highest protection

**Corresponding author*

in each case of the test as expected which is in agreement with previous work Ginger oil resulted in the longest duration of 100% repellency (3 to 4 hours) against the *Anopheles dirus* species of mosquito.

Keywords: Turmeric; mosquito; repellent activity.

1. INTRODUCTION

"The tropical and sub-tropical regions of the world today are majorly affected by vector-borne diseases" (Sink et al., 2012). "Mosquito is the main source of vector transmission of malaria, and dengue has the potential of transmitting to more than 750 million people every year. Over 3 million people lost their lives annually, Out of which 90% of the mortality are usually infants" [1]. The ability to prevent mosquito-borne diseases, control mosquito larval growth and personal protection from mosquito bites by the use of mosquito nets and mosquito repellent are the most popular and common methods in use [2]. "Scholars in environmental sciences and other fields use scientific innovations which include mosquito vaccines, but it is still at a nascent level and is not yet recommended for human use" [3]. Also, "a number of global supports to control mosquitoes do exist and the most familiar and easiest way is by the application of repellents. Repellents may effectively protect humans from vector-borne diseases as well as other mosquito related problems. N,N-Diethyl-meta toluamide, (DEET) is the active component in the chemical-based mosquito repellent and it is easily accessible. However, several limitations of DEET have been documented due to its ability to cause local skin irritation, including erythema and pruritis, at the site of application. Furthermore, it can also cause severe sensory disturbance and affect motor capacity, memory, and learning ability [4]. Cinnamon bark (*C. cassia*), Turmeric (*Curcuma longa – L*), Garlic (*Allium sativum – L*), Ginger (*Zingiber officinale* – Roscoe), Black pepper (*P. nigrum – L.*) and Lemon grass (C. citratus) are the potential natural mosquito repellent" [5]. Based on chemical nature, these medicinal plants contain a mixture of many compounds including isoprenoids mono and sesquiterpenes (Cheng et al., 2003). "These chemicals can act as carriers of the smell which are richly found in aromatic plants. Previous research by scholars has shown that they possess repellent activity against mosquitoes. However, there have been many concerns about the repellent properties of many kinds of essential oils because most of the results came from artificial (*in vitro*) testing methods using cloth, filter paper, animal membrane, or olfactometry although some came from more realistic (*in vitro*) methods that utilizes animals or human subjects" [6]. "Reports from different methods adopted cannot be compared directly because these methods yield results that can strongly be related to the laboratory conditions used. The analysis of repellency should preferably be carried out using human subjects, because laboratory animals have the tendency to simulate the condition of human skin inadequately to which repellents will eventually be applied" [7]. Therefore, the present study intends to characterize the relationship between four concentrations of five selected essential oils against *Aedes aegypti* mosquitoes using human subjects with caged mosquitoes. The more effective oils were also studied for their repellent activities against *Anopheles dirus*.

2. MATERIALS AND METHODS

2.1 Essential Oils

The 5 essential oils namely; Turmeric (*C.longa*), Garlic (*Allium sativum*), Ginger (*Z. officinale* – Roscoe), Black pepper (*P. nigrum*) and Lemon grass (*C. citratus*) were obtained from Jos North Plateau State Capital Nigeria. Herbarium specimens were identified by a botanist and deposited at the Herbarium Unit College of Forestry Plateau State. They were subsequently extracted for essential oils by steam distillation. About 1 kg at a time of fresh plant material was cut into small pieces and placed in a distillation flask of about three times as much water. The distillation chamber was heated to about 120 °C and allowed to boil until the distillation was completed. The distillate was collected in a separating funnel with which the aqueous portion could be separated from the oil. These oils were kept at 4 °C until they were tested for mosquito repellency.

2.2 Essential oils Yields

The yield of each essential oil was recorded as shown in Table 2. The yield of the oil was calculated using the formula:

$$Yield\ of\ essential\ oil\ (\%) = \frac{\text{Amount of essential oil obtained (g)}}{\text{Amount of raw materials used (g)}} \text{ X } 100\%$$

2.3 Mosquitoes

The *Aedes aegypti* mosquitoes were uninfected laboratory strains and were reared in the insectary of the Insecticide Research Unit at the Department of Science Laboratory Technology University of Jos, Faculty of Natural Sciences University of Jos. The methods for mass rearing are similar to the procedure described in the previous work but witha slight modifications [8].

2.4 Subjects

The research used four human subjects who agreed to take part in testing the repellency of each kind of oil.

2.5 Repellent Assay

The repellency potential of the essential oils was evaluated by using an arm-in-cage test [9]. Each oil extracted from the plant was tested undiluted and also was diluted with 80% alcohol to 5%, 10%, and 15% concentration. An arm was covered with a rubber sleeve with a 3 × 10 cm window and 0.2 mL of a 5%, 10% and 15% concentration, as well as the undiluted oil, was applied. The treated arm was exposed for 2 min to 200 hungry female mosquitoes. Every 30 min after treatment the treated arm was re-exposed to mosquitoes and the duration at which the first bite occurred was recorded. The arm exposure at 30-min intervals continued until two bites occurred and one further exposure was made to check that complete repellency could no longer occur. The time of complete repellency after application of repellent was used as the basis for repellency of the essential oils. The control used was the arm treated with the solvent used for the essential oil. The arm used as a control was exposed before the start of each assay. The essential oils that provided the longest complete protection time were tested against *Aedes aegypti* by the same methods.

3. RESULTS

The results of the initial screening tests showing the repellent activity of five essential oils from plants are given in Table 2.

4. DISCUSSION

Five essential plants were collected from Faringada Area of Jos North, Plateau State Nigeria. Leaves of lemongrass, Ginger, Garlic, Black pepper, and Turmeric were collected in January, March, and April 2022, at weather conditions presented in Table 1.

4.1 Extraction Yields

Leaves of lemongrass, Ginger, Garlic, Black pepper, and Turmeric were harvested during the daytime. The yields were as follows; lemongrass (3.9), Ginger (2.7), Garlic (2.8), Black pepper (2.4), and turmeric (3.2) respectively. The yields shown in Table 2, obtained by steam distillation technique were superior to those found in the previous literature work by Marques [10] who found 0.17% and Castelo et al. [11] found 0.10%. Differences between yields can best be explained by considering whether younger or older leaves were harvested, although extreme care was observed to guarantee the uniform collection and this may be the reason for a better yield in some of the plants than in others even the quantity of the leaves harvested were the same. Favorito [12] observed that young leaves contain more trichomes (that is morphologic structures) that produce essential oil. However, damage to the leaves caused by fungus and other insects can also damage glands that produce essential oils.

Table 1. Weather Conditions for Collection Months

Weather condition	March	April	January
Max. temperature (◦ C)	34.50	34.00	28.00
Min. temperature (◦ C)	19.50	21.42	21.40
Humidity (%)	26 .00	45.00	24.00

Table 2. Extraction yields of essential oils % oil Yield (w/w) of five essential oils extracted from plants

Quantity (kg)	Lemon grass	Ginger	Garlic	Black pepper	Turmeric
1	3.9	2.7	2.8	2.4	3.2

Weight of oil obtained (g) Ginger 27g, Tumeric 32g, Black pepper 24g, Garlic 28g and lemongrass 39 g

Table 3. Repellent activity of 5 essential oils (undiluted, 5%, 10% and 15% dilutions) against *Ae. aegypti* mosquitoes (Duration (min) of complete repellency)

S/N	Oil	5%	10%	15%	Undiluted	Control
1	*C.citratus*	0	30.30.30;(30)	30.30.30;(30)	30.30.60;(40)	0
2	*A.sativum*	0.10.20;(10)	10.50.60;(40)	60.60.90;(70)	60.60.120;(80)	0
3	*C.longa*	0	0.0.30;(10)	0.0.30;(10)	0.30.30;(20)	0
4	*Z.offcinae*	0	0	30.30.60;(40)	30.60.60;(50)	0
5	*P.nigrum*	0	0	90.60.90;(30)	90.90.90;(90)	0

4.2 Repellency

"The repellency potential of five essential oils from different plants was carried out using human subjects, as testing repellents on animals or artificial membranes may not give representative data of how the repellent may perform when applied to human skin" [13]. This research work evaluated the repellent activities of five oils against *Ae. aegypt*i mosquitoes which were reared under laboratory conditions and are avid biters. The results showed that of 5 undiluted essential oils, the most effective were extracted from *P. nigrum* and *A. sativum* which provided complete repellency for 90 and 80 minutes respectively when compared to the other three (Table 3). The results are similar to a reports of United States Department of Agriculture [14] which also documented the complete repellency of certain essential oil of *S. aromaticum* and *C. nardus* as high as 120 min against *Ae. aegypti*.The recommendation of the US Environmental Protection Agency [15], about using *Ae. aegypti* along with a representative human-biting species from both the *Anopheles* and *Culex* genera for the laboratory studies of repellent efficacy can reveal information concerning differences in response of the main vector genera of mosquitoes. The patterns of sensitivity to repellent compounds varied between mosquito genera Rutledge et al. [16]. Also in the *Ae. Aegypti* repellency test, the traditional test species for repellent studies, was an exceptionally poor predictor for the responses of *An. stephensi* to repellents. It was reported that Anopheles mosquitoes were less sensitive to DEET and other repellent chemicals than *Ae. Aegypti* Curtis et al. [17]. The results recorded in this research showed that of the 5 oils tested, the undiluted oil of *C. citratus*, *C. longa, A. sativum, Z. officinale* and *P. nigrum* provided better protection against *Ae. aegypti,* when compared to the 5%,10% and 15% dilution. The mean duration of repellency of *P. nigrum* oil was slightly greater than the other four oils against *Ae. aegypti,* (90 min).

The ability of oils to manifest mosquito repellency depends on the protection time thus an increase in time requires increasing oil concentration. All of the oils could not prevent mosquito biting for as long as 90 min when used at 5%, 10%, or 15% concentration.

Low-income rural communities in most African countries where the highest incidence of mosquito-borne diseases are reported, this research has revealed the potency of cheaply available *P. nigrum* and *A. sativum* to the list of effective plant based repellents in its undiluted or low dilution form and the tendency of having better yield under certain season of the year. These plants contain has several insect repellent chemicals under certain environmental conditions, the content of volatile oils in plants may vary significantly. The repellent compounds contained in these essential oils include alpha pinene, camphene, camphor, geraniol and terpenen-4-ol and most abundant repellent molecules found in the group are citronellal, citronellol and geraniol [18].

5. CONCLUSION

The plants have pleasant smells and are used widely in traditional medicine. More research are needed to develop appropriate formulations like creams, gels and other fixative could increase their efficacy and cost effectiveness. More so,

trials should be carried out in the field to evaluate the feasibility and dermal toxicity over a long duration of time, especially in infants and children.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Mahapatra DK, Bharti SK, Asati V. Chalcone scaffolds as antiinfective agents: Structural and molecular target perspectives. 2015;101:496-524.
2. Guillet P, Alnwick D, Cham MK, Neira M, Zaim M, Heymann D, Mukelabai K. Long-lasting treated mosquito nets: a breakthrough in malaria prevention. Bull World Health Org. 2001; 79(10):998.
3. Girard MP, Reed ZH, Friede M, Kieny MP. A review of human vaccine research and development: malaria. Vaccine. 2007; 25(9):1567-1580.
4. Dechovskaia A, Abou-Donia MB, Goldstein LB. Effect of daily dermal application of DEET and permethrin, alone and in combination, on sensorimotor performance, blood brain barrier and blood testes barrier in rats. Journal of Toxicology and Environmental Health Part A. 2001;62: 523-541.
5. Baietto M. Bud fall induction in clove *(Syzygium aromaticum).* Academic Research International. 2014;5:23-29.
6. Rutledge LC, Ward RA, Gould DJ. Studies on the feeding response of mosquitoes to native solutions in a new membrane feeder. Mosquito News. 1964;24:407–419.
7. Barnard DR.Repellents and toxicants for personal protection. *In Global Collaboration for Development of Pesticides for Public Health (GCDPP). WHO/CDS/WHOPES/ GCDPP/2000.5* WHO;2000.
8. Limsuwan S, Rongsriyam Y, Kerdpibule V, Apiwathanasorn C, Chiang GL, Cheong WH. Rearing techniques for mos quitoes. In Entomology Malaria and Filariasis – Practical Entomology Malaria and Filariasis, Sucharit S, Supavej S (eds). Museum and Reference Center, Faculty of Tropical Medicine, Mahidol University: Bangkok;1987.
9. Schreck CE, McGovern TP.Repellents and other personal protection strategies against Aedes albopictus. J Am Mosq Control Assoc. 1989;5:247–252.
10. Marques TP. Subsidies to the recovery of riparian forest formations of Araucaria Forest of Parana State, from the use of non-wood forest products species [M.S. thesis], Federal University of Parana (UFPA);2007.
11. Castelo VM, Del Menezzi CHS, Resck IS. Yield and spectroscopic analysis (1 H,13C NMR; IR) of essential oils from four plants of the Brazilian Savannah. Cerne. 2010;16(4):573–584.
12. Favorito S. *Tricomas secretores de Lippia stachyoides cham. (verbenaceae):* estrutura, ontogenese e secrecao [M.S. thesis] , Bioscience Institute, UNESP, 2009.
13. Cockcroft A, Cosgrove JB, Wood RJ.Comparative repellency of commercial formulations of deet, permethrin and citronellal against the mosquito *Aedes aegypti*, using a collagen membrane technique compared with human arm tests. Med Vet Entomol. 1998;12:289–294.
14. US. Department of Agriculture (USDA). 1952–1964. Materials evaluated as insecticides, repellents and chemosterilants at Orlando and Gainesville, FLA. Agriculture Handbook No. 340. Agricultural Research Service, USDA. U.S. Government Printing: Washington DC.
15. US EPA.. Product performance test guideline OPPTS 810.3700 Insect repellents for human skin and outdoor premises. United States Environmental Protection Agency, Washington D.C. Office of Prevention, Pesticides and Toxic substances;2003.
Available:http://www.epa.gov/opptsfrs/oppts_harmonized/810_product_performance_Test_Guideline/Drafts/ 810-3700.pdf
16. Rutledge LC, Collister DM, Meixsell VE, Eisenberg GHG. Comparative sensitivity of representative mosquitoes (Diptera: Culicidae) to repellents. J Med Entomol. 1983;20:506–510.
17. Curtis CF, Lines JD, Ijumba J, Callagham A, Hill N, Karimzad MA. The relative efficiency of repellents against mosquito vectors of disease. Med Vet Entomol. 1987;1:109–119

18. Duke J. USDA Agricultural Research Service Phytoche mical and Ethnobotanical Database ;2000. Available:http:www.ars-grin.gov/ lmfugrlsb

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/86101