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Skin applied mosquito repellent — Specification — Part 2: Sprays and roll-ons

EAST AFRICAN COMMUNITY

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DEAS FOR EQUIRY STAGE

Foreword

Development of the East African Standards has been necessitated by the need for harmonizing requirements governing quality of products and services in the East African Community. It is envisaged that through harmonized standardization, trade barriers that are encountered when goods and services are exchanged within the Community will be removed.

The Community has established an East African Standards Committee (EASC) mandated to develop and issue East African Standards (EAS). The Committee is composed of representatives of the National Standards Bodies in Partner States, together with the representatives from the public and private sector organizations in the community.

East African Standards are developed through Technical Committees that are representative of key stakeholders including government, academia, consumer groups, private sector and other interested parties. Draft East African Standards are circulated to stakeholders through the National Standards Bodies in the Partner States. The comments received are discussed and incorporated before finalization of standards, in accordance with the Principles and procedures for development of East African Standards.

East African Standards are subject to review, to keep pace with technological advances. Users of the East African Standards are therefore expected to ensure that they always have the latest versions of the standards they are implementing.

The committee responsible for this document is Technical Committee EASC/TC 078, *Healthcare and medical devices*.

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DEAS 1119 consists of the following parts, under the general title *Skin applied mosquito repellents — Specification*:

- *Part 1: Lotions, creams, gels and ointments*
- *Part 2: Sprays and roll-ons*
- *Part 3: Wipes*
- *Part 4: Bathing soaps*
- *Part 5: Bracelets, wristbands and patches*
- *Part 6: Jelly*

Skin applied mosquito repellent — Specification — Part 2: Sprays and roll-ons

1 Scope

This Draft East African Standard specifies the requirements, sampling and test methods for skin applied mosquito repellents in form of sprays and roll-ons.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

AOAC 997.07, *N-octyl bicycloheptene dicarboximide*

EAS 346, *Labelling of cosmetic products — General requirements*

EAS 377 (all parts), *Cosmetics and cosmetic products*

EAS 846, *Glossary of terms relating to the cosmetic industry*

EAS 847-16, *Cosmetics — Analytical methods — Part 16: Determination of Heavy Metal Content*

EAS 847-17, *Cosmetics — Analytical methods — Part 17: Physio-chemical test*

ISO 18416, *Cosmetics — Microbiology — Detection of *Candida albicans**

ISO 21149, *Cosmetics — Microbiology — Enumeration and detection of aerobic mesophilic bacteria*

ISO 22717, *Cosmetics — Microbiology — Detection of *Pseudomonas aeruginosa**

ISO 22718, *Cosmetics — Microbiology — Detection of *Staphylococcus aureus**

ISO 24153, *Random sampling and randomization procedures*

DEAS 1120-1, *Mosquito repellents — Performance test guidelines — Part 1: Skin applied repellents*

3 Terms and definitions

For the purposes of this document, the following terms and definitions given in EAS 846 and the following apply. ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at <http://www.iso.org/obp>

3.1 mosquito
blood-sucking dipterous insect of the family Culicidae. Aedes, Anopheles, Culex, Mansonia, and Stegomyia are genera containing most species involved in the transmission of protozoan and other disease-causing parasites.

3.2 mosquito repellent
substance applied to deter mosquito from approaching or settling.

3.3 natural repellent
repellent that contain, plant-based compounds

3.4 synthetic repellent
conventional repellent containing chemical compounds manufactured to imitate the natural compounds

3.5 roll-on
cosmetic preparation with the effect of deodorizing and providing antiperspirant properties to the body of the user. It is packed in a container fitted with a roll-ball.

3.6 roll-ball
spherically shaped object, with the capacity to roll in all directions. It is put at the opening of a roll-on container and serves the role of closing the container as well as dispensing the contents, when rolled on the skin

4 Forms

4.1 The mosquito repellent shall be in the form of:

- a) sprays
- b) roll-ons

4.2 The spray shall consist of a liquid formulation in a pressurised, non-refillable dispenser, containing active ingredient(s), and/or synergist(s) and other formulants including propellants and solvents. It may be packaged in aerosol or non-aerosol dispensers.

4.3 The roll on shall also be in form of cosmetic preparation meant to be applied as a roll-on, and which contains active ingredient(s), synergist(s) and/or other formulants.

5 Requirements

5.1 General requirements

5.1.1 The mosquito repellent shall contain required amounts of active ingredients and when applied to the skin shall have the effect of repelling mosquitos.

5.1.2 The formulation shall be of uniform colour and shall be free from visible impurities.

5.1.3 The aerosols shall not contain solvents and propellants listed in Annex A.

5.1.4 All ingredients shall conform to all parts of EAS 377

5.1.5 When applied to the skin, the mosquito repellent shall have the benefit of repelling mosquitoes and shall not have a harmful effect to the skin.

5.1.6 The deviation from the declared content of the active ingredient shall not be more than 1 %.

5.2 Active ingredients and synergists

5.2.1 Natural repellents

5.2.1.1 Active ingredients used in natural repellents shall be natural plant based active ingredients such as essential oils or any other plant extract approved as mosquito repellents.

5.2.1.2 The manufacturer shall provide adequate data on the repellence of such ingredients.

5.2.1.3 The manufacturer shall have adequate data justifying the proportion of ingredient(s) for which claims are made, used in the product.

5.2.1.4 The essential oils used in natural repellents shall be safe for users and provide the required efficacy. Annex H gives some ingredients (essential oils) and safe concentration commonly used in natural repellents.

5.2.1.5 The concentration of plant-based active ingredient and recommended application shall be safe to the user and provide the required efficacy. Annex I provides the efficacy of some plant-based mosquito repellents.

5.2.2 Synthetic repellents

5.2.2.1 Synthetic repellents shall contain chemical compounds which are able to deter mosquitoes from approaching or settling on the surface

5.2.2.2 The concentration of the active ingredients and the recommended application/use shall ensure the declared efficacy and shall be safe and proved by scientific evidence.

5.2.2.3 Synthetic repellents and their active ingredients shall be approved and registered by relevant authority before being released to the market. Annex J gives the list of some of active ingredients used in synthetic repellents

5.2.3 Synergist content

5.2.3.1 The synergist content shall be declared and, when determined, the average content measured shall not differ from that declared.

5.2.3.2 The synergist used shall include the following but not be limited to:

- a) piperonyl butoxide (PBO);
- b) sesame seed oil (sesamin, sesamol); and/or
- c) N-Octyl bicycloheptene dicarboximide (MGK 264).

5.2.3.3 The synergist shall be tested in accordance with AOAC 997.07. The ratio of the active ingredient to the synergist shall be indicated and records availed.

5.2.3.4 The ratio of the active ingredient to the synergist shall be at the ratio range of 1 to 10 parts exponent's active ingredient to 1 part of a repellent's active ingredient

5.3 Specific requirements

The mosquito repellent shall comply with the specific requirements given in table 1.

Table 1 — Specific requirements for skin applied mosquito repellents in form of sprays and roll-ons

| S/N | Parameter | Requirement | Test method |
|-----|---------------------------------|-------------|-------------|
| i | pH | 3 – 7 | EAS 847-17 |
| ii | Non-volatile matter, % m/m, min | 10 | Annex B |

5.4 Heavy metal contaminants

The products shall comply with the heavy metal limits given in Table 2 when tested in accordance with the test methods specified therein.

Table 2 — Heavy metal limits for skin applied mosquito repellents in form of sprays and roll-ons

| S/No | Heavy metals | Maximum Limit ^a , mg/kg | Test method |
|------|--------------|------------------------------------|-------------|
| i | Lead | 10 | EAS 847-16 |
| ii | Arsenic | 2 | |
| iii | Mercury | 2 | |

^a The total amount of heavy metals as lead, mercury and arsenic, in combination, in the finished product shall not exceed 10 mg/kg.

5.5 Microbiological limits

The product shall comply with the microbiological limits given in Table 3 when tested in accordance with the test methods specified therein.

Table 3 — Microbiology limits for skin applied mosquito repellents in form of sprays and roll-ons

| S/No | Microorganism | Requirement | Test method |
|------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------|-------------|
| i | Total viable count, CFU/g or CFU/ml, max. <ul style="list-style-type: none"> • Products for children below three years • Other products | 100 | ISO 21149 |
| | | 1000 | |
| ii | <i>Staphylococcus aureus</i> (per g or per ml) | Not detected | ISO 22718 |
| iii | <i>Pseudomonas aeruginosa</i> (per g or per ml) | Not detected | ISO 22717 |
| iv | <i>Candida albicans</i> (per g or per ml) | Not detected | ISO 18416 |

5.6 Requirements for aerosol containers

The product packaged in aerosol containers shall meet the requirements given in Table 4.

Table 4 — Specific requirements for aerosol containers.

| S/N | Parameter | Requirement | Test method |
|-----|---------------------------------|--------------|-------------|
| i | CFCs | Absent | Annex C |
| ii | Delivery rate g/s, min | 0.01 | Annex D |
| iii | Net weight delivery, % m/m, min | 95 | Annex E |
| iv | General leakage | To pass test | Annex F |

5.7 Biological efficacy

When tested in accordance with DEAS 1120-1, the product shall repel 100% of the mosquitoes from approaching or settling on that surface, within protection time indicated by the manufacturer.

6 Packaging

The product shall be packaged in suitable well sealed containers that shall protect the contents and shall not react with the product or cause any contamination during storage, handling or use.

6.1 Roll ball construction

If the container is fitted with a roll-on;

- a) the roll ball shall be made of plastic material.
- b) the roll ball shall be fitting on the container such that on holding the container inside down the contents shall not pour out.
- c) the roll ball shall be free rolling, leaving a thin layer of the contents on the skin during dispensation.

6.2 Aerosol containers

Filled aerosol containers shall be appropriately classified in terms of flame propagation characteristics of their contents when tested in accordance with Annex G.

- i. Highly flammable — if the average length of the flame is greater than 0.45 m or if the flame burns back to the actuator, or continues to burn when the test flame is extinguished.
- ii. Flammable — if the average length of the flame is between 0.20 m and 0.45 m.
- iii. Non-flammable — if the product does not burn in the manner described above (Highly flammable) and (Flammable)

7 Labelling

In addition to the labelling requirements given in EAS 346, the package shall be legibly and indelibly labelled in English and/or any other official language (French, Kiswahili, etc.) used in the importing East African Partner State with the following information:

- a) name of the product as mosquito repellent;
- b) form of the product, as “roll-on” or “spray”;

- c) name and physical address of the manufacturer;
- d) batch number;
- e) date of manufacture;
- f) date of expiry;
- g) quantity in the container;
- h) list of active ingredient (s) and their concentration.;
- i) list of other ingredients;
- j) net mass of content;
- k) directions for use;
- l) safety precaution;
- m) special persons whose exposure is prohibited (out of reach of children and pregnant women);
- n) disposal instructions; and
- o) storage conditions.

8 Sampling

Sampling shall be in accordance with ISO 24153.

Annex A (normative)

Solvents not permitted for use in aerosols

- a) Benzene
- b) 2-butoxyethanol (ethylene glycol monobutyl ether)
- c) 2-butoxyethylacetate (ethylene glycol monobutyl ether acetate)
- d) carbon tetrachloride
- e) chlorobenzene
- f) chloroform
- g) 1,2-dichloroethane (ethylene dichloride)
- h) 2-ethoxyethanol (ethylene glycol monoethyl ether)
- i) 2-ethoxyethylacetate (ethylene glycol monoethyl ether acetate)
- j) n-hexane
- k) 2-hexanone (methyl n-butyl ketone)
- l) 2-methoxyethanol (ethylene glycol monomethyl ether)
- m) 2-methoxyethylacetate (ethylene glycol monomethyl ether acetate)
- n) tetrachloroethylene
- o) trichloroethylene
- p) Propellants

Note: Hydrocarbon propellants are recommended for insecticide aerosols, provided international safety standards are met by the aerosol producer. Industry should be encouraged to develop alternative and safer propellants and delivery systems.

Annex B (normative)

Non-volatile matter

B.1 Apparatus

B.1.1 Moisture dish

B.1.2 Oven

B.1.3 Analytical balance

B.1.4 Desiccator

B.2 Procedure

Weigh accurately $1\text{g} \pm 0.2\text{g}$ of the sample in the dish and place it in an oven at $105\text{ °C} \pm 2\text{ °C}$ for 1 h. Cool to room temperature in a desiccator and weigh the dish. Repeat the process to bring it to constant mass.

B.3 Calculation

The non-volatile matter content, expressed as percent, shall be calculated as follows;

$$\frac{M_2 - M_1}{M} \times 100$$

where,

M mass, in grams of the material taken;

M₁ mass in grams of the dry and empty dish, and

M₂ mass in grams of the dish and dried material

Annex C (normative)

Determination of propellant composition

C.1 Procedure

C.1.1 The analysis of the propellant mixture in most aerosols is carried out conveniently by gas chromatography. For Sampling, a hypodermic needle is fitted to the valve of the aerosol can and approximately 0.5 g of the propellant is injected into the heavy duty centrifuge tube closed with serum cap, containing about 8 ml of benzene. After mixing, 5 μ l samples are taken out from this tube with a microlitre syringe and injected into the gas chromatograph.

C.1.2 Two 4572 mm \times 6.35 mm OD columns operated at 40 °C are recommended for the analysis containing 20 percent weight hexadecane and diethylhexyl sebacate respectively on silanized chromosorb W60/S0 mesh.

C.1.3 The first column should be used mainly for initial screening and the second column for the confirmation and determination of the identified propellants.

C.1.4 Table C1 lists the relative retention data of the most widely used propellant together with some other fluorinate hydrocarbons and benzene used as the solvent IN the two columns.

Table C.1 — Relative retention data of propellants

| Chemical name | Stationary phase diethylhexyl sebacate | Stationary phase hexadecane |
|-----------------------------------------|----------------------------------------|-----------------------------|
| Octafluorocyclobutane | 0.214 | 0.122 |
| 1-chloro-1,2,2 trifluoroethylene | 0.268 | 0.196 |
| Propane | 0.275 | 0.22 |
| 1,2-difluoroethane | 0.289 | 0.141 |
| Dichlorodifluoromethane | 0.296 | 0.220 |
| 1,2-dichloro-1,1,2,2-tetrafluoromethane | 0.345 | 0.290 |
| Isobutane | 0.366 | 0.378 |
| Monochlorodifluoromethane | 0.368 | 0.152 |
| 1-Chloro-1,1-difluoroethane | 0.402 | 0.236 |
| n- butane | 0.449 | 0.527 |
| Vinylchloride | 0.529 | 0.353 |
| Trichlorofluoroethane | 1.000 | 1.000 |
| 1,1,2-trichloro-1,2,2-tetrafluoroethane | 1.254 | 1.342 |
| Dichloromonofluoroethane | 1.354 | 0.515 |
| 1,2-dibromo-1,1,2,2 tetrafluoroethane | 1.634 | 1.363 |
| Methylene Chloride | 2.565 | 1.070 |
| Benzene | 6.786 | 5.661 |

C.2 Results

The sample shall be considered as having failed the test if it contains any of the above CFCs.

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Annex D (normative)

Determination of delivery rate of the dispenser

D.1 Material and apparatus

The following material and apparatus shall be used in this test

D.1.1 Stop watch

D.1.2 Balance

Having accuracy to 0.01 g and with a capacity greater than 500 g.

D.1.3 Pair of gloves

Made of cloth or fabric or towel for handling dispensers during test.

D.1.4 Pair of tongs

For removing dispensers from water bath.

D.1.5 Water bath

Set at 26 °C ± 0.3 °C, thermostatically controlled.

D.2 Procedure

D.2.1 Hold a dispenser upright, spray for two seconds to fill the education tube. Then weigh the dispenser

D.2.2 Submerge the dispenser into the water bath for 15 minutes using tongs, remove the dispenser from the bath and immediately dry the container with a towel Spray the dispenser in one continuous burst for 10 seconds. Re-weigh the dispenser.

D.2.3 Repeat the procedure and take an average of three tests. The difference between the maximum and minimum delivery rates shall not exceed 0.2 g per second.

D.3 Calculation

The delivery rate, expressed as gram/second, shall be calculated as follows;

$$\text{Delivery rate (in g per second)} = \frac{M_1 - M_2}{N}$$

where,

M_1 initial weight of the dispenser in grams

M_2 final weight of the dispenser in grams

N time in seconds

Annex E (normative)

Net weight delivery

E.1 For the determination of the net weight delivery, a random sample of at least three packages is selected. After the removal of any dust cover or caps not required for dispensing the product, the gross weight of each package is determined and after shaking for 15 S, the content of the lightest container is drained by holding the valve wide open. Now the exhausted container is weighed. The result is called wet – tare weight and is equal to the weight of the container plus any product remaining after draining.

E.2 Consequently, the regeneration allowance is determined and subtracted from the wet-tare weight to obtain the corrected wet-tare weight. The regeneration allowance is defined as the difference between the weight of the product which would be delivered through normal usage and the weight of the product delivered by the present accelerated procedure. It is calculated by multiplying the label weight of the container by 0.02 g and rounding the result to the next lowest gram.

E.3 By subtracting the corrected tare weight from the gross weight, the adjusted net weight of the package is obtained. If this is greater than 95 % of the label weight the lot is assumed to be satisfactory. However, if it is less than 95 % of the label weight, the lot is rejected.

Annex F (normative)

Testing of filled aerosol containers

F.1 Procedure

F.1.1 All filled aerosol containers shall be tested by immersion in a water bath set at 55 °C.

F.1.2 The container shall be such that the pressure generated within the immersed container reaches not less than 90 percent of the pressure generated within the containers at equilibrium at 55 °C.

F.2 Interpretation of results

Any filled aerosol container that shall leak, get distorted or burst as a result of this test shall be considered to have failed the test and shall be discarded.

Annex G (normative)

Flame propagation

G.1 Principle

The filled aerosol container is sprayed as a test flame under controlled conditions and length of the burning spray cone is measured.

G.2 Apparatus

G.2.1 In its simplest form, the apparatus consists of a base marked at 0.15 m intervals, an adjustable stand to carry the aerosol container which may be raised or lowered to accommodate differences in container height, a means of measuring the burning spray cone (usually a one metre ruler placed horizontally at the same level as the top third of the flame, the hottest part) a means of igniting the spray cone in the form of a test flame 0.05 m \pm 0.005 m in height (usually a candle flame is used).

G.2.2 Water bath maintained at 20 °C. This equipment shall be used to bring the aerosol container and its contents to equilibrium at 20 °C (Heat the cans to 20 °C in the water bath).

G.3 Procedure

G.3.1 Place the aerosol container on the stand. Depress the actuator and adjust the height of the stand so that the spray cone will pass through the upper third test flame (hottest part).

G.3.2 Bring the aerosol container and its content to the equilibrium temperature of 20 °C. Place the container on the stand so that the point where the spray emerges is 0.15 m from the test flame. Then light the test flame and depress the actuator for 15 seconds to 20 seconds. Record the total length of the burning spray cone and specify whether or not it burns back to the actuator.

G.3.3 Extinguish the test flame and record whether the spray cone continues to burn while the actuator is depressed.

G.3.4 Repeat each test twice and record the flame length as the average of the three tests

Annex H informative

Some common essential oils in natural repellents that may be hazardous

Table H1 — Some common ingredients (essential oils) in natural repellents that may be hazardous

| Common name | Scientific name | Safe concentration (%) | Hazard |
|-----------------------|-------------------------------------------------------------------------------------------------------------------|------------------------|------------------------------------------------------------------------------------------------------|
| Anise | <i>Pimpinella anisum</i> | 3.6 | Based on 0.11 % methyl eugenol; carcinogen |
| Basil | <i>Ocimum sp.</i> | 0.07 | Based on 6 % methyl eugenol; carcinogen. |
| Bergamot | <i>Citrus</i> | 0.1 | Sensitising and phototoxic; skin irritant. |
| Cajeput | <i>bergamia</i> | 0.004 | Based on 97 % methyl eugenol; carcinogen. |
| Cedar | <i>Melaleuca alternifolia</i> | 1 | Likely allergenic contaminants if nootkatone not 98 % pure. |
| Cinnamomium | <i>Cinnamomium cassia</i> | 9 | Sensitising skin irritant |
| | <i>Cinnamomum verum</i> | 0.05 | Based on 75.5 % of cinnamaldehyde, sensitising skin irritant. |
| Citronella | <i>Cymbopogon nardus</i> | 2 | Safety is controversial; based on 0.2% methyl eugenol or 1.3 % citral; sensitising skin irritant. |
| | | 18.2 | Based on 29.1 % geraniol, sensitising skin irritant |
| Citronella (java) | <i>Cymbopogon winterianus</i> | 2 | Based on 2 % methyl eugenol; carcinogen |
| Citrus oils | <i>Citrus sp.</i> | 16 – 25 | Based on 0.005 % - 0.0025 % bergapten; phototoxic skin irritant |
| Clove | <i>Syzyguim aromaticum</i> | 0.5 | Based on 92 % eugenol; sensitising skin irritant. |
| Eucalyptus | <i>E.globulus,</i> <i>E.globulusmaidenii;</i> <i>E.radiata;</i> <i>E.smithii,</i> <i>E.camaldulensis</i> | 20 | High in 1,8-Cineole can cause Central Nervous System (CNS) and breathing problems in young children. |
| Fever tea, lemon bush | <i>Lippie javanica</i> | 2 | Based on 5 % citral in related species; sensitising skin irritant. |
| Geranium | <i>Pelargonium graveolens</i> | 6 | Based on 1.5 % citral; sensitising skin irritant |
| | <i>Pelargonium x asperum</i> | 17.5 | Based on 30.3 % geraniol; sensitising skin irritant. |

| | | | |
|--------------------------|------------------------------------------------|---------------------------|----------------------------------------------------------------------|
| Ginger | <i>Zingber sp.</i> | 12 | Based on 0.8 citral; sensitising skin irritant. |
| Huon oil, Macquarie pine | <i>Langarostrobos franklini</i> | 0.004 | Based on methyl euginol; |
| Huon oil, Macquarie pine | <i>Langarostrobos franklini</i> | 0.004 | Based on methyl euginol; carcinogen. |
| Lemongrass | <i>Cymbopogon citrates</i> | 0.1 | Based on 90 % citral; sensitising skin irritant. |
| Lime | <i>Citrus aurantifolia</i> | 0.7 | Phototoxic skin irritant. |
| Litsea | <i>Litsea cubeba</i> | 0.1 | Based on 78 % cotral; sensitising skin irritant |
| Marigold | <i>Tagates minuta</i> | 0.01 | Phototoxic skin irritant |
| Mint | <i>Menthe piperata and spicata</i> | 2 | Based on 0.1 % trans-2-hexenal; sensitising skin irritant |
| Nutmeg | <i>Myristica fragrans</i> | 0.4 | Based on 1 % methyl euginol; carcinogen. |
| Palmarosa | <i>Cymbopogon martini</i> | 16 | Based on 1.2% farnesol; sensitizing skin irritant. |
| Pine | <i>Pinus sylvestris</i> | Prepare with antioxidants | Oxidation creates phototoxic skin irritants |
| Rosemary | <i>Rosemarinus officinalis</i> | 36 | Based on 0.011% methyl euginol; carcinogen. |
| | | 16.5 | High in Camphor CT (Chemotype) |
| | | 22 | High in α -Pinene CT |
| | | 6.5 | High in Verbenone CT |
| Rue | <i>Rota chalepensis</i> | 0.15 | Based on presence of psoralenes; phototoxic skin irritant. |
| Tea tree | <i>Tea tree</i> | Tea tree | Tea tree |
| | <i>Leptospermum petersonii (lemon scented)</i> | 0.6 | Based on 76.7 % Citral (Geranial +Neral), sensitising skin irritant. |
| Thyme | <i>Thymus vulgaris</i> | 2 | Based on 0.1 % trans-2-hexenal; sensitising skin irritant. |
| Violet | <i>Viola odorata</i> | 2 | Based on 0.1 % trans-2-hexenal; sensitizing skin irritant. |
| Ylang-ylang | <i>Canagium odoratum</i> | 2 | Based on 4 % farnesol; sensitizing skin irritant |

Annex I (informative)

Plant-based insect repellents: a review of their efficacy, development and testing

Plant-based repellents have been used for generations in traditional practice as a personal protection measure against host-seeking mosquitoes. Knowledge on traditional repellent plants obtained through ethnobotanical studies is a valuable resource for the development of new natural products. Recently, commercial repellent products containing plant-based ingredients have gained increasing popularity among consumers, as these are commonly perceived as “safe” in comparison to long-established synthetic repellents although this is sometimes a misconception. Table I.1 gives an overview of repellent plant efficacy from literature review.

Table I.1 — An overview of repellent plant efficacy from literature review

| Plant | Location | Other names | Repellent compound (s) | Tested mode of use | Repellency % protection |
|----------------------------|-----------|------------------|--------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------|----------------------------------------------------------------------------------|
| Myrtaceae | | | | | |
| <i>Corymbia citriodora</i> | Australia | Lemon eucalyptus | Citronellal PMD (by product of hydrodistillation) (p-methane-3,8-diol) Citronellol Limonene Geraniol Isopulegol δ-pinene | 30 % PMD applied topically | 96.88% protection from mosquitoes for 4 hours |
| | Brazil | Lemon | | PMD towelette (0.57g) applied topically | 90% protection from <i>An. Arabiensis</i> for 6 hours. |
| | Bolivia | Scented | | 50 % PMD applied topically | 100% protection from <i>An. Gambiae</i> and <i>An. Funestus</i> for 6 – 7 hours. |
| | China | Gum Quwenling | | 20 % PMD (1.7 mg/cm ²) applied topically. | 100% protection for 11 – 12 hours against <i>A. stephensi</i> . |
| | India | | | 20 % PMD applied topically | 100% protection against <i>Ae. Aegypti</i> for 120 minutes. |
| | Ethiopia | | | Thermal expulsion (leaves) | 78.7% protection from <i>An. Arabiensis</i> . |
| | Tanzania | | | Direct burning (leaves) | 70.1% protection from <i>An. arabiensis</i> |
| | Kenya | | | Periodic thermal expulsion (leaves) | 74.5% protection from <i>An. Gambiae</i> s.s. |
| | | | | Periodic direct burning (leaves) | 51.3% protection from <i>An. Gambiae</i> s.s. |

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|----------------------------------------------------------------------------------------------------|---------------------------------------------------|-----------------------------------|--------------------------------------------------------------------------|------------------------------------------------------------|----------------------------------------------------------------------------|
| | | | | Thermal expulsion (leaves) | 48.71% protection from <i>An. Gambiae</i> s.l. |
| <i>Eucalyptus spp.</i> | Guinea-Bissau Ethiopia Tanzania Portugal | Eucalyptus | 1,8-cineole citronellal Z- and α - citral α - pinene | Thermal expulsion (leaves) | 72.2% protection from mosquitoes for 2 hours |
| <i>E.camaldulensis</i> | Ethiopia | | | Thermal expulsion (leaves) | 72.2% protection from <i>An.Pharaoensis</i> |
| | | | | | 71.9% protection from <i>An. Arabiensis</i> |
| | | | | Direct burning (leaves) | 66.6% protection from <i>An.Pharaoensis</i> |
| | | | | | 65.3% protection from <i>An. Arabiensis</i> |
| <i>Eugenia caryophyllus</i> or <i>Syzygium aromaticum</i> or <i>Eugenia aromatic</i> | India | Clove lavang cravinho-da india | Euginol Carvacrol Thymol Cinnamaldehyde | 100 % essential oil applied topically | 100% protection against <i>Ae. aegypti</i> for 225 minutes |
| | | | | | 100% protection against <i>An. Albimanus</i> for 213 minutes |
| | | | | 100 % essential oil applied topically | 100% protection against <i>Ae. aegypti</i> for 120 min. |
| | | | | | 100% protection against <i>C. quinquefasciatu</i> s for 240 min. |
| | | | | | 100% protection against <i>An. Dirus</i> for 210 min. |
| Verbenaceae | | | | | |
| <i>lippia spp.</i> | Kenya Tanzania Ghana Zimbabwe | Lemon bush | Myrcene Linalool α - pinene eucalyptol | | |
| <i>L. javanica</i> | | | Alloparinol Camphor Limonene α - terpeneol verbenone | 5 mg/cm ² plant extract applied topically | 100% protection against <i>Ae. aegypti</i> for 8 hours |
| | | | | Alcohol plant extract applied topically | 76.7% protection against <i>An. Arabiensis</i> for 4 hours |

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|-----------------------------------------|-----------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------|--------------------------------------------------------------------------------|
| <i>L. uckambensis</i> | | Fever tea | | Potted plant | 33.3% protection against <i>An. Gambiae</i> s.s |
| | | | | Periodic thermal expulsion (leaves) | 45.9% protection against <i>An. Gambiae</i> s.s |
| | | | | Periodic direct burning (leaves) | 45.9% protection against <i>An. Gambiae</i> s.s |
| | | | | Potted plant | 25.01% protection against <i>An. Gambiae</i> s.s |
| <i>L. cheraliera</i> | | | Eucalyptol Caryophyllene lpsdienone p-cymene | | |
| <i>Lantana camara</i> | Kenya Tanzania | Lantana Spanish flag West Indian Lantana Wild sage | Caryophyllene | Potted plant | 32.4% protection against <i>An. Gambiae</i> s.s |
| | | | | Potted plant | 27.22% protection against <i>An. Gambiae</i> s.l |
| | | | | Flower extract in coconut oil | 94.5% protection against <i>aegypti</i> and <i>ae. albopictus</i> for one hour |
| | | | | Periodic thermal expulsion (leaves) | 42.4% protection against <i>An. Gambiae</i> s.s |
| Lamiaceae | | | | | |
| <i>ocimum</i> spp. <i>O. americanum</i> | Kenya Tanzania Zimbabwe Nigeria Ghana Cameroon Eritrea Ethiopia (...) | Tree basil Nchu avum Lime basil Kivumbasi Myeni Madongo African blue Basil Hairy basil | p-cymene estragosol linalool linoleic acid eucalyptol eugenol camphor citral thujone limonene ocimene and others | Potted plant | 39.70% protection against <i>An. Gambiae</i> s.s |
| | | | | Potted plant | 37.91% protection against <i>An. Gambiae</i> s.l |
| | | | | Fresh plants combined with <i>O. suavebruis</i> and applied topically | 50% protection against <i>An. Gambiae</i> s.l |
| | | | | Periodic thermal expulsion (leaves and seeds) | 43.1% protection against <i>An. Gambiae</i> s.s |
| | | | | Periodic direct | 20.9% |

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|--------------------------------------------|-----------------------------------------------|--|--|----------------------------------------------------------------|----------------------------------------------------------------|
| | | | | burning (leaves and seeds) | protection against <i>An. Gambiae s.s</i> |
| | | | | 100% essential oil combined with vanillin 5% applied topically | 100% protection against <i>Ae. aegypti</i> for 6.5 hours |
| | | | | | 100% protection against <i>C. quinquefasciatus</i> for 8 hours |
| | | | | | 100% protection against <i>An. Dirus</i> for 8 hours |
| <i>O. suave</i> | | | | Thermal expulsion (leaves) | 73.6% protection from <i>An. Arbiensis</i> |
| | | | | | 75.1% protection against <i>An. pharaoensis</i> |
| | | | | Direct burning (leaves) | 71.5% protection from <i>An. arbiensis</i> |
| | | | | | 79.7% protection against <i>An. pharaoensis</i> |
| | | | | Periodic thermal expulsion (leaves and seeds) | 53.1% protection from <i>An. gambiae s.s.</i> |
| Periodic direct burning (leaves and seeds) | 28.0% protection from <i>An. gambiae s.s.</i> | | | | |
| <i>O. basilicum</i> | | | | Thermal expulsion (leaves) | 78.7% protection from <i>An. arabiensis</i> |
| | | | | | 79.2% protection from <i>An. pharaoensis</i> |
| | | | | Direct burning (leaves) | 73.1% protection from <i>An. arabiensis</i> |
| | | | | | 70.0% protection from <i>An. pharaoensis</i> |
| 100% essential oil applied topically | 100% protection for 70 minutes. | | | | |
| <i>O. kilimandscharikum</i> | | | | Thermal expulsion (leaves and seeds) | 44.54% protection against <i>An.</i> |

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|------------------------------------------------|--------------------------------------------------------------------------|-------------------------------------------------------------------|--------------------------------------------------------------------------|---------------------------------------------------|--------------------------------------------------------------------------|
| | | | | | gambiae s.l. |
| | | | | Thermal expulsion (leaves and seeds) | 37.63% protection against <i>An. funestus</i> . |
| | | | | Periodic thermal expulsion (leaves and seeds) | 52.0% protection against <i>An. gambiae</i> s.s. |
| | | | | Periodic direct burning (leaves and seeds) | 26.4% protection against <i>An. gambiae</i> s.s. |
| <i>O. forskolei</i> | | | | Fresh plants hung indoors | 53% protection against mosquitoes entering human dwelling |
| <i>Hyptis</i> spp. <i>Hyptis suaveolens</i> | Kenya Tanzania Ghana The Gambiae | Bushmint Wild hops Wild Spikenard Hangzimu Hortela-do | Myrcene | Smouldering on charcoal | 85.4% repellency against mosquitoes for 2 hours |
| | | | | Fresh leaves | 73.2% repellency against mosquitoes for 2 hours. |
| | | | | Periodic direct burning (leaves and flowers) | 20.8% repellency against <i>An. gambiae</i> s.s. |
| <i>Mentha</i> spp. <i>M. piperata</i> | Brazil Bolivia | Hortela-do-campo Peppermint | | 100% essential oil applied topically | 100% protection against <i>Ae. aegypti</i> for 45 minutes. |
| <i>M. arvensis</i> | | Menta Japanese mint | | 100% essential oil volatilized in a kerosene lamp | 41% protection against indoors against <i>Mansonia</i> spp. |
| <i>Thymus</i> spp. <i>Th. vulgaris</i> | China Former Union Soviet Union Korea Middle-East Mediterranean | Thyme | α -terpinene carvacrol thymol p-cymene linalool geraniol | α -terpinene topically | 97.3% protection against <i>Culex pipiens</i> <i>sallens</i> for 82 min. |
| | | | | Carvacrol topically | 94.7% protection against <i>C. pipiens</i> <i>sallens</i> for 80 min. |
| | | | | Thymol topically | 91.8% protection against <i>C. pipiens</i> <i>sallens</i> for 70 min |
| | | | | Linalool topically | 91.7% protection |

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|--------------------------|-------------------------------|-----------|-------------|---------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| | | | | | against <i>C. pipiens sallens</i> for 65 min |
| | | | | p-cymene | 89.0% protection against <i>C. pipiens sallens</i> for 45.2 min |
| | | | | 100 % essential oil applied topically | 100% protection against <i>An. Arbimanus</i> for 105 min and <i>Ae. aegypti</i> for 135 min. |
| | | | | Direct burning (leaves) | 85-90% protection for 60-90 min. |
| <i>Pogostemon spp.</i> | China | Patchouli | | 100% essential oil applied topically | 100% protection against <i>Ae. aegypti</i> for 120 min. |
| <i>Pogostemon cablin</i> | India Malaysia Thailand | Oriza | | 100% essential oil applied topically | 100% protection against <i>C. quinquefasciatus</i> for 150 min. 100% protection against <i>An. Dirus</i> for 710 min. |
| Poaceae | | | | | |
| Cymbopogon | China India Indonesia | | | | |
| <i>C. nardus</i> | Brazil | | citronellal | 40% essential oil applied topically | 100% protection for 7-8 hours against <i>An. Stephensi</i> |
| | | | | 100% essential oil applied topically | 100% protection against <i>Ae. Aegypti</i> for 120 min. 100% protection against <i>C. quinquefasciatus</i> for 100 min. 100% protection against <i>An. dirus</i> for 70 min. |
| | | | | 10% essential oil applied topically | 100% protection against <i>Ae. Aegypti</i> for 20 min. |

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|------------------------------|--------------------------------|----------------|--------------------------|-----------------------------------------------------------------|-------------------------------------------------------------------|
| <i>C. martini</i> | Tanzania Kenya | palmarosa | geraniol | 100% essential oil applied topically | 100% protection against <i>An. culicifacies</i> for 12 hours. |
| | | | | | 96.3% protection against <i>C. quinquefasciatus</i> for 12 hours. |
| | | | | Topically (100% essential oil) | 98.8% protection against <i>C. quinquefasciatus</i> for 10 hours. |
| <i>C. citratus</i> | USA South Africa Bolivia | Lemongrass oil | Citral α - pinene | Topically (100% essential oil) | 74% protection against <i>An. Darlingi</i> for 2.5 hours |
| | | | | | 95% protection against <i>Mansonia</i> spp. for 2.5 hours |
| | | | | Methanol leaf extract applied topically (2.5mg/m ²) | 78.8% protection against <i>An. Arabiensis</i> for 12 hours |
| | | | | 100% essential oil applied topically | 100% protection for 30 minutes |
| <i>C. winterianus</i> | | | | 100% essential oil combined with vanillin 5% applied topically | 100% protection against <i>Ae. Aegypti</i> for 6.5 hours |
| | | | | | 100% protection against <i>C. quinquefasciatus</i> for 8 hours |
| | | | | | 100% protection against <i>An. Dirus</i> for 8 hours |
| <i>C. excavatus</i> | | | | extract applied topically | 66.7% protection against <i>An. Arabiensis</i> for 3 hours |
| <i>Pelargonium Reniforme</i> | | Rose Geranium | | Alcohol extract plant applied topically | 63.3% protection against <i>An. Arabiensis</i> for 3 hours |
| Meliaceae | | | | | |
| <i>Azadirachta indica</i> | India SriLanka China | Neem | Azadirachtin saponins | Direct burning (leaves) | 76.0% protection from mosquitoes for |

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|--------------------------|---------------------------------------------------------------------------|------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------|--------------------------------------------------|---------------------------------------------------------------------------------------------------|
| | Brazil Bolivia Pakistan Ethiopia Guinea Bissau Kenya Tanzania | | | | 2 hours |
| | | | | Periodic thermal expulsion (leaves) | 24.5% protection from <i>An. Gambiae</i> s.s. |
| | | | | 1% neem oil volatilized in a kerosene lamp | 94.2% protection from <i>Anopheles spp.</i> 80% protection from <i>Culex spp.</i> |
| | | | | 2% neem oil applied topically | 56.75% protection from mosquitoes for 4 hours |
| Asteraceae | | | | | |
| <i>Tagetes minuta</i> | Uganda Zimbabwe India | Khaki weed | | Topically | 86.4% protection against <i>An.</i> <i>Stephensi</i> for 6 hours |
| | | | | Topically | 84.2% protection against <i>C.</i> <i>quinquefasciatu</i> <i>s</i> for 6 hours |
| | | | | Topically | 75% protection against <i>Ae.</i> <i>Aegypti</i> for 6 hours |
| | | | | Fresh leaves (4kg) | Reduced human landings indoors |
| <i>Artemisia ssp.</i> | | | | | |
| <i>A. vulgaris</i> | India Egypt Italy Canada USA | Mugwort wormwood St. Johns plant Old uncle henry Sailors Tobacco | Camphor Linalool Terpenen-4-ol α - and β - thujone β - pinene | | |
| <i>A. monosperma</i> | Siberia Brazil | Felon herb Naughty man | Myrcene Limonene Cineol | 5% leave extract applied topically | 100% protection for 4 hours |
| Caesalpiniaceae | | | | | |
| <i>Daniellia oliveri</i> | Guinea-Bissau The Gambiae | Churai Santao Santang Santango | | Direct burning (bark) | 77.9% protection against mosquitoes for 2 hours |
| | | | | Direct burning (bark) | 77% protection against mosquitoes |
| Fabaceae | | | | | |

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|-----------------------------|-------------------------------------------|---------------------------------------|--|----------------------------------------------------------------|--------------------------------------------------------------------|
| Glycine max | Worldwide | Soya | | 2% soya bean oil | 100% protection against <i>Ae. Aegypti</i> for 95 minutes |
| Rutaceae | | | | | |
| <i>anthoxylum limonella</i> | Thailand | makaen | | 100% essential oil applied topically | 100% protection against <i>Ae. Aegypti</i> for 120 minutes |
| | | | | | 100% protection against <i>C. quinquefasciatus</i> for 170 minutes |
| | | | | 10% essential oil combined with vanillin 5% applied topically | 100% protection against <i>An. dirus</i> for 95 minutes |
| <i>Citrus hystrix</i> | Indonesia Malaysia Thailand Laos | Kaffir lime Limau Purut | | 100% essential oil combined with vanillin 5% applied topically | 100% protection against <i>An. Stephensi</i> for 8 hours |
| | | | | | 100% protection against <i>Ae. Aegypti</i> for 3 hours |
| | | | | | 100% protection against <i>C. quinquefasciatus</i> for 1.5 hours |
| | | | | | 100% protection against <i>An. dirus</i> |
| Zingiberaceae | | | | | |
| <i>Curcuma longa</i> | | Turmeric Curcuma Indian saffron | | 100% essential oil combined with vanillin 5% applied topically | 100% protection against <i>Ae. Aegypti</i> for 4.5 hours |
| | | | | | 100% protection against <i>C. quinquefasciatus</i> for 8 hours |
| | | | | | 100% protection against <i>An. dirus</i> for 8 hours |

Annex J (Informative)

Active ingredients for synthetic repellents

Table J1 – List of some active ingredients for synthetic repellents

| Active ingredient | Assessing risks to Health | Assessing risks to Environment |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p>DEET</p> <p>DEET, which is an acronym for N,N-Diethyl-meta-toluamide, is one of the most effective bug repellents and also repels ticks.</p> | <p>Large doses of DEET have been linked to skin blisters, seizures, memory loss, headaches, stiffness in the joints shortness of breath, and skin irritation. DEET is also linked to neurotoxicity that may lead to physiological and behavioral problems, especially with motor skills, and learning and memory dysfunction.</p> | <p>DEET is absorbed quickly through the skin: one study showed that 48 % of the applied dose is totally absorbed within six hours. When mixed with the sunscreen chemical oxybenzone, it was found to be absorbed even more quickly. DEET has been shown to cross the placenta: in animal studies, DEET was found in the fetus and in newborns up to three months old after exposing the mother to the chemical.</p> |
| <p>IR 3535</p> <p>3-[N-Butyl-N-acetyl]-aminopropionic acid, ethyl ester is structurally related to #-alanine, which occurs naturally. The active ingredient is a liquid at room temperature.</p> | <p>IR3535 has been used as an insect repellent in Europe for 20 years with no substantial adverse effects. Toxicity tests show that the IR3535 is not harmful when ingested, inhaled, or used on skin. Eye irritation could occur if the chemical enters a person's eyes. Any allergic reactions are required to be reported to EPA</p> | <p>Because the active ingredient is used only in products applied to human skin, no risks to the environment are expected</p> |
| <p>PMD</p> <p>(p-Menthane-3,8-diol p-Menthane-3,8-diol occurs naturally in the lemon eucalyptus plant. The natural oil can be extracted from the eucalyptus leaves and twigs. For commercial use, the active ingredient is chemically synthesized. pMenthane-3,8-diol is structurally similar to menthol.</p> | <p>In studies using laboratory animals, p-Menthane-3,8-diol shows no adverse effects except for eye irritation. Therefore, special precautions were put on the label to prevent the product from contacting people's eyes. For example, "Do not get in eyes. Do not apply on face or hands of small children." and "Do not spray directly on or near face. Instead, spray in palm of hand and spread on face and neck." If used according to label instructions, pMenthane-3,8-diol is not expected to pose health risks to people, including children and other sensitive populations</p> | <p>Based on laboratory animal studies, p-Menthane-3,8-diol poses minimal or no risks to wildlife. Because of the low toxicity and limited uses of pMenthane-3,8-diol, it is not harmful to the environment</p> |
| <p>Picaridin</p> <p>1-(1-methylpropoxycarbonyl)-2-(2hydroxyethyl) piperidine or 2-(2hydroxyethyl)-1-piperidinecarboxylic acid 1-methylpropyl ester. Picaridin is an insect repellent that is applied directly to the skin. Picaridin appears to work by preventing the mosquito finding or recognizing its host. Picaridin products can be formulated as solids, liquids, sprays, aerosols, or wipes.</p> | <p>Picaridin generally is of low acute toxicity, and based on the available toxicological data, the Agency believes that the normal use of Picaridin does not present a health concern to the general U.S. population</p> | <p>Based on the ecological effects data submitted by the registrant, the Agency concluded that the product should pose no risks to terrestrial and aquatic organisms from the proposed use pattern. The use should provide non-target organisms extremely limited access to the chemical.</p> |

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| <p>2-undecanone (Methyl nonyl ketone)</p> <p>is a dog and cat repellent/training aid and iris borer deterrent. The pesticide is used in households, paths, patios, solid waste containers and on ornamental plants. Methyl nonyl ketone is formulated as a pressurized liquid, granular, liquid ready-to-use (pump/sprayer), solid (crystalline), and liquid for reformulating use only. EPA assumes that the volume of use of this pesticide is relatively low.</p> | <p>Based on the current use patterns and exposure profiles for methyl nonyl ketone, no dietary or occupational risk characterizations are required since residues in or on food/feed are not expected to occur and no toxicological endpoints of concern for either short or intermediated terms were identified.</p> | <p>Due to the repellent nature of the product, risks to non-target terrestrial species is not likely. In addition, nontarget aquatic species exposure is unlikely because this chemical is neither persistent nor mobile in the environment and associated use patterns.</p> |
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DEAS FOR EQUIRY STAGE