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Formulation of Paint and Detergent with *Pelargonium citrosum* & *Rosmarinus officinalis* Extracts as *Musca domestica* Repellent Agent

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Authors' contributions

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

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ABSTRACT

Use of botanical environmentally friendly and biodegradable insect repellants as opposed to chemical insecticides is increasingly becoming important as an alternative method of insect control. Housefly (*Musca domestica* L.) has potential of transmitting pathogen causing diseases such as typhoid, cholera, bacillary dysentery, tuberculosis, anthrax, ophthalmia, and parasitic worms. Essential oils derived from aromatic plants have exhibited biological properties and can be used to prevent and treat human diseases. The aim of this study was to formulate the housefly repellent paint and detergent. Extraction of essential oils was by hydro-distillation. Condensed oil extracts were collected in n-hexane and insect behavioral response tested using adult houseflies (*Musca domestica* L.). *N, N*-diethyl-*m*-toluamide (DEET) was used as the positive control and acetone as

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the negative control. The formulated products showed higher repellent activities against the housefly. When 1% (V/V %) insect repellent detergent and paint were compared, the housefly repellent activities occurred at 67±2.64 for detergent and 76±1.34 for the paint. When 3% (V/V%) insect repellent detergent and paint were compared, the housefly repellent activities occurred at 81±1.77 for detergent and 84±2.1 for the paint for outdoor and indoor field trials which were carried out for eight hours each day for two days. The results provide scientific rationale for traditional use of *R. officinalis* oil and *Pelargonium citrosum* in control of housefly and other common insects in the household.

Keywords: LD_{50}; LD_{75}; Musca domestica L; P. citrosum and R. officinalis.

1. INTRODUCTION

Housefly (*Musca domestica*) has potential of transmitting more than a hundred pathogen causing diseases to human and animals such as typhoid, cholera, bacillary dysentery, tuberculosis, anthrax, ophthalmia, and parasitic worms [1]. Management and control of housefly relied upon the use of chemical insecticides such as organochlorides, organophosphates and pyrethroids, etc. Presently bio-insecticide from plants origin has been increasingly evaluated in controlling insects. Plants contain bioactive organic chemicals in the form of metabolites and plant extracts have been used locally in herbal preparation to cure ailments even before the advent of orthodox medicine in many developing countries [2]. Flavonoids, alkaloids, saponins, sesquiterpenes, limonoids, phenols, stubenes and coumains of plant origin have been found to possess toxic growth regulating and antifeedant effects against a host of insect pests [3].

Rosmarinus officinalis is a woody perennial herb with fragrant evergreen, needle-like leaves and white, pink, purple or blue flowers native to the Mediterranean region and Asia. It is a member of the mint family (lamiaceal) which includes many other herbs. It forms range from upright to trailing. The upright forms can reach 1.5 m (5ft) tall. Upon cultivation the leaves, twigs and flowering apices are extracted for use. Rosemary is used as a decorative plant in gardens where it may have pest control effects. The leaves are used to flavor various foods such as stubbing and roast meat.

Pelargonium citrosum is a perennial sub-shrub with fragrant leaves that are reminiscent citronella. It is marketed as mosquito plant in the United States and Canada. Chemical analysis by the authors revealed that combined essential oils of fresh greenhouse and field grown citrosa have 35.4%, 6.2% geraniol, 10.4% citronellol, 8.9% isomenthone and 6.8% linalool. The effectiveness of the citrosa as a repellent against field populations of spring *Aedes* spp mosquitoes were evaluated and compared with a 75% DEET (N, N-diethyl-*m*-toluamide) formulation.

2. MATERIALS AND METHODS

2.1 Sample Collection and Extraction

The leaves of Pelargonium citrosum and Rosmarinus officinalis were collected from Githunguri in Kiambu County, based on their reported ethnobotanical information as insect repellents. The fresh leaves were washed with running tap water and cut into small pieces, air dried at room temperature then pulverized with an in-house mechanical blender. Extraction of essential oils from the ground plant samples were done through hydro-distillation using Clevenger apparatus. The condensed extract was extracted with n-hexane and filtered using Whatman® grade 1 filter paper containing anhydrous Sodium Sulphate to remove any traces of water. Hexane was then removed by distillation at 60°C using 'Contes' Short Path distillation, and the collected oil weighed into smaller amber covered vials and stored at 4°C ready for repellency tests. The percentage yield of the extracts was; 7.28% for *R. officinalis* and 10.43% for *P. citrosum*.

2.2 Complexing of Plant Active Extracts Using Iron (ii) Chloride

The synthesis of Iron complex was done by adding 0.01 M Ferrous Chloride and the *R. officinalis* extract in 2:5 proportion in a clean sterilized flask. The reaction mixture was kept in the magnetic hot stirrer at 50-60°C for an hour to occur color change from pale green to brown which denoted the metal ion oxidation. The main factors, pH was maintained between 3 and 4 hours the temperature was at 50-60°C throughout the experiment. The solution was centrifuged (350 rpm for ten minutes) and the supernatant was discarded and the pellet was washed with distilled water and was centrifuged again to remove any impurities. Complexing of *P. citrosum* extract was also done in the same way.

2.3 Characterization of the Complexes

2.3.1 FT-IR analysis

FT-IR spectrum in the range 4000 to 400 cm^{-1} at a resolution of 4 cm^{-1} using Perkin-Elmer spectrometer was used to detect the functional groups in the complex. The sample was mixed with KBr. Thin sample disc was prepared by pressing with the disc preparing machine and placed in Fourier Transform Infra-Red (FTIR) for the analysis of the complex [4].

2.3.2 UV-visible spectra analysis

The UV-Visible absorption spectra of the complexes were measured on a Shimadzu UV-VIS 530A spectrophotometer in the range of 200-800 nm. The absorption peaks of the complexes and those of the pure extracts were compared and the shift in the absorption peaks were recorded [5].

2.4 Preparation of Housefly Repellent Detergent

2.4.1 Preparation of soap less detergent (100 Kgs)

Sodium lauryl ether sulfate	: 5 kg
Alkyl aryl sulphonic acid	: 2.5 kg
Sodium carbonate	: 5 kg
Carboxy methyl cellulose	: 100 mgs
Species colour	: 50 mgs
Sodium hydroxide	: 50 mgs
Perfume (pine oil dissolved in ester solvent).	: 20 mgs
Water	: up to100

Considering the probit analysis results obtained and the calculated values of LC_{50} and LC_{75}, the housefly repellent detergent was prepared by mixing the plant extract with 5% glycerin and the extract was then incorporated into the pre-prepared detergent. Glycerin was used as an emulsifier in this procedure. The total active ingredients in the detergent were 2% (V/V) and all the constituents were mixed using the mechanical stirrer for one hour. Finally, the mixture was poured into plastic containers and the repellency test performed on the product.

2.4.2 Preparation of the housefly repellent paint

Considering the probit analysis results obtained and the calculated values of LC_{50} and LC_{75} from the iron complexed plant extract, the housefly repellent paint was prepared by dissolving the Iron complexed plant extract in ethyl acetate. Glycerin 5%, was then added and then incorporated into the pre-prepared paint. Glycerin was used as an emulsifier in this procedure. The total active ingredients in the detergent were 1% (V/V) and all the constituents were mixed using the mechanical stirrer for one hour. Finally, the mixture was poured into plastic containers and the repellency test performed on the product.

2.5 Bio-efficacy Testing of the Housefly Repellent Detergent and Paint

Bio-efficacy tests of the housefly repellent detergent and paint were performed both in the laboratory and in the field. The laboratory analysis was done by dissolving the repellent product in distilled water then applied on a bench with a rotten meat on top. Adult houseflies were released and the time of contact between the housefly and the bench recorded for eight hours. Another bench was cleaned using the normal detergent and used as control for this experiment.

The field analysis was conducted in three restaurants around Juja area in Kiambu County. The housefly repellent detergent was used to clean the floor, walls and tables of one room and another room cleaned using the normal detergent. An observation was done for eight hours in both the rooms for the presence of the housefly. The housefly repellent paint was also tested by applying on the walls and observation was done for four months for the presence of the housefly. The normal emulsion paint was used as control for this experiment.

3. RESULTS AND DISCUSSION

Tables 1 and 2 shows the percentage repellency of the detergent and paint products respectively.

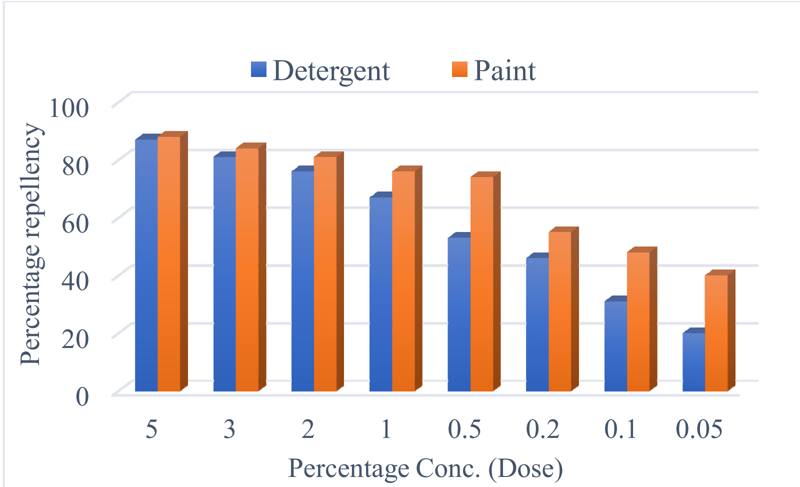

Fig. 1. Comparison between the repellency activities of housefly repellent paint and detergent

From the results in the Fig. 1, the findings indicate high housefly repellency demonstrated by the two formulated products. Comparing the two products, the housefly repellent paint showed slightly higher repellency against the target insect more than the detergent. According to the indoor and outdoor field trials which were carried out, both the housefly repellent paint and the housefly repellent detergent have shown more than 87% housefly repellence.

3.1 Probit Analysis

Lethal dose at 50% and at 75% concentration is presented in Tables 3 and 4.

Table 1. Percentage repellency activity of detergent product

% CONC (dose)	AVE % ± STDEV
0.05	20±1.63
0.1	31±1.90
0.2	46±3.33
0.5	53±2.02
1	67±2.64
2	76±1.50
3	81±1.77
5	87±1.61

3.2 Characterization Using the FTIR

Figs. 1- 2 represent the absorption spectra of the samples of essential oil obtained from the complexed extracts of *R. officinalis* and *P. citrosum* measured in the wavelength range 4000-1000 cm^{-1}, with a resolution of 4 cm^{-1}. The spectrum of the uncomplexed extracts for each sample is represented in figures 3 and 4. The region 1400- 400 cm-1 (fingerprint) of the IR spectrum contains absorption bands that characterize the entire molecular structure by vibrations of the spectrum: deformation, combining, harmonic bands that cannot generally be attributed to normal vibrations.

Table 2. Percentage repellency activity of paint product

% CONC (dose)	AVE % ± STDEV
5	88±1.51
3	84±2.33
2	81±1.50
1	76±1.61
0.5	74±1.77
0.3	66±1.90
0.2	55±2.64
0.1	48±2.31
0.05	40±1.11
0.025	36±1.00

Some of the bands observed in the complexed spectrum were different in intensity compared to those of the uncomplexed extract. Bands located at around 1850, and 3403 cm^{-1}, corresponding to carbonyl, and the hydroxyl groups respectively present in the complexed extracts were at slightly different locations from those of the uncomplexed extract where the main functional groups observed were C=O at 1710 cm-1 and broad O-H spectrum at around 3500 cm-1. The shifting of

Table 3. Determination of LC50 and LC75 of the detergent product

	CONC(dose)%	AVE % ±STDEV	% repellency	log of Conc.	probit
	0.05	20±1.63	20	-1.30	4.16
	0.1	31±1.90	31	-1.00	4.5
	0.2	46±3.33	46	-0.70	4.9
	0.5	53±2.02	53	-0.30	5.08
	1	67±2.64	67	0.00	5.44
	2	76±1.50	76	0.30	5.71
	3	81±1.77	81	0.48	5.88
	5	87±1.61	87	0.70	6.13
Intercept	5.441	**Determination of LC50**		**Determination of LC75**	
X Variable 1	0.948	Y = ax+c		Y = ax + c	
		5 = 0.948X+5.441		5.67 =0.948x+ 5.441	
		X = -0.4652		X = 0.242	
		LC50 = 0.343		**LC75 = 1.744**	

Table 4. Determination of LC50 and LC75 of the paint product

Concentration	Log 10 of Conc.	% Repellency(of the complex)	Probit
5	0.6989	88	6.18
3	0.4771	84	5.99
2	0.3010	81	5.88
1	0	76	5.71
0.5	-0.3010	74	5.64
0.3	-0.5228	66	5.41
0.2	-0.6989	55	5.13
0.1	-1	48	4.95
0.05	-1.3010	40	4.76
0.025	-1.6021	36	4.64
Intercept	5.7014		
X Variable 1	0.6898		
Determination of LC50			Determination of LC75
Y= aX + C			Y= aX + C
5= 0.6899X + 5.7014			5.67= 0.6899X + 5.7014
X= -1.0167			X=-0.0455
LC50 =0.0962			LC75 = 0.90

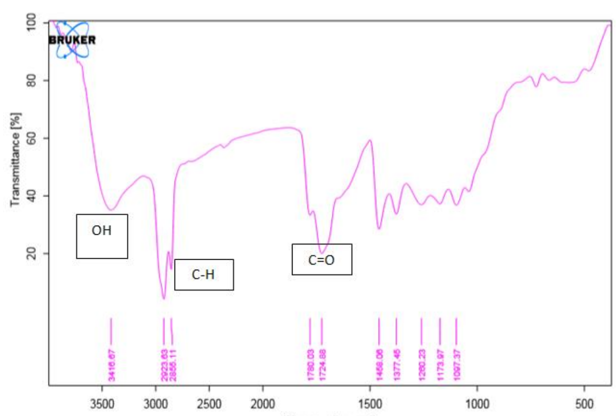

Fig. 2. FTIR spectrum of *R. officinalis* complexed with iron (ii) chloride

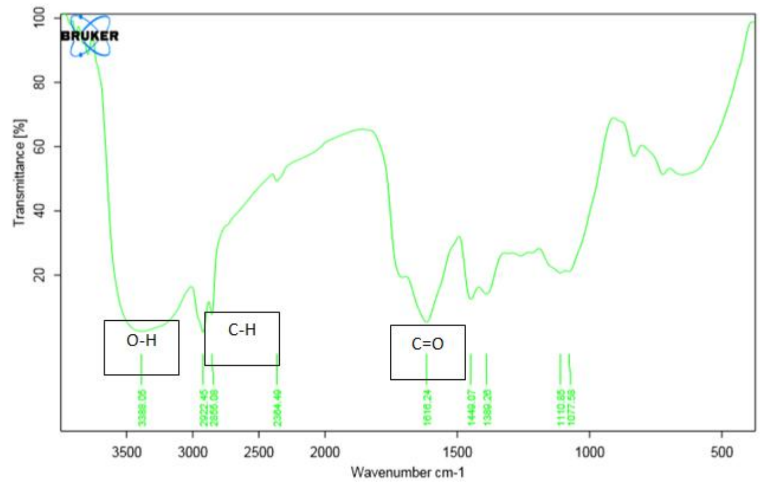

Fig. 3. FTIR spectrum of *P. citrosum* complexed with iron (ii) chloride

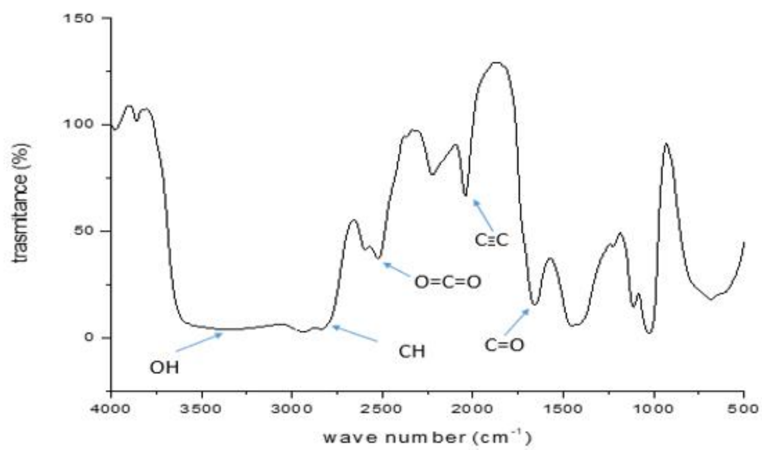

Fig. 4. FTIR spectrum of *R. officinalis*

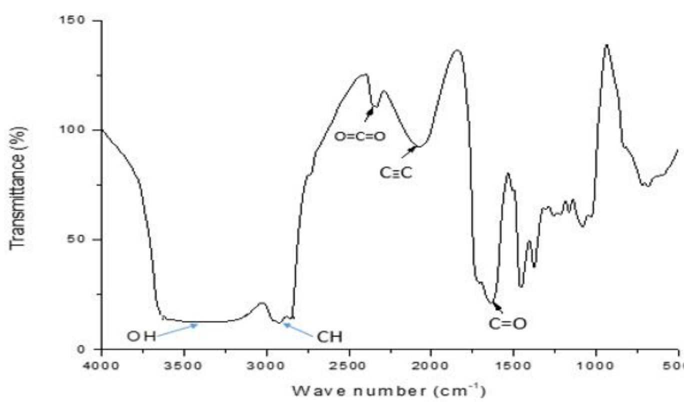

Fig. 5. FTIR spectrum of *P. citrosum*

the carbonyl group in the complexed extract could be due to the formation of the metal carbonyl while the sharpening of the OH peak at around 3400 cm-1 is attributed to the loss of the carboxylic acid hydrogen bonding.

4. CONCLUSION

The formulated products showed higher repellent activities against the housefly. When 1% (V/V %) insect repellent detergent and paint were compared, the housefly repellent activities occurred at 67±2.64 for detergent and 76±1.34 for the paint. When 3% (V/V%) insect repellent detergent and paint were compared, the housefly repellent activities occurred at 81±1.77 for detergent and 84±2.1 for the paint for outdoor and indoor field trials which were carried out for eight hours each day for two days.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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