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Comparative Bio-activity Guided Characterization of Biocide from *Jatropha curcas* and *Ricinus communis* L Seeds Oil

Asnake G. Ede *, Abebe G. Demissie

ABSTRACT

This study reports the characterization of biocide from Jatropha (*Jatropha curcas*) and castor (Ricinus *communis* L) seeds oil. The biocide potential of *the* seeds oil was evaluated against termite (*Odontotermes obesus*) and cockroach (*Blattella germanica*). The bioassay study showed that Jatropha 10% oil caused 100% mortality in 48 hrs. and 72 hrs. against termite and cockroach, respectively. Castor 10% oil caused 100% mortality in 60 hrs. and 72 hrs. against termite and cockroach, respectively. The LD_{50} was determined to be 0.64% and 1.24% for termite and cockroach, respectively for jatropha oil after 72 hrs. exposure. It was determined to be 1.43% and 1.08% for termite and cockroach respectively for castor oil. The biocidal potential of the oil is statistically significant ($p<0.05$) when compared with blank and solvent controls at all concentration tested. Various physicochemical parameters were also evaluated in accordance with American standard testing method specifications.

Keywords: Anti-Termite, Anti-Cockroach, Biopesticide, Physicochemical Parameters.

Asnake G. Ede
Arba Minch University, College of Natural Sciences, P.O.Box 21, Arba Minch 21, Ethiopia.
E-mail: *astuasnegude@gmail.com*

Abebe G. Demissie,
Arba Minch University, College of Natural Sciences, P.O.Box 21, Arba Minch 21, Ethiopia.
E-mail: *abebetse@yahoo.com*

Correspondence:
Asnake G. Ede
Arba Minch University, College of Natural Sciences, P.O.Box 21, Arba Minch 21, Ethiopia.
E-mail: astuasnegude@gmail.com

1. Introduction

Plant-derived oils have been shown to possess insecticidal, anti-fungal, and antibacterial properties [3, 8, 4, 12]. Satyawati [15] found that *J. curcas* is used as traditional herbal medicines due to their anti-platelet-aggregative, diuretic, antifungal, and anti-inflammatory activities. All parts of *J. curcas* have been used in traditional medicine and for veterinary purposes for a long time [5]. Recently, the substances responsible for wound healing and anti-inflammatory effects have been isolated and characterized [13, 18]. Various extracts from *J. curcas* seed and leaves showed molluscicidal, insecticidal and fungicidal properties [11, 14, 17]. Phorbol esters have been suggested to be one of the toxic principles [16]. In addition to their acute toxic effects, they also have numerous sub-lethal effects, acting as larval growth inhibitors, antifeedants, and repellents to a wide range of insects, mites and even nematodes, all of which are consistent with an octopaminergic mode-of-action.

The kernels of *J. curcas* contain between 0.03 and 3.4% of phorbol esters (depending on the variety), which can be expressed with the oil [7, 19]. The methanol extract of the crude oil was even more active with LD_{50} values of 0.004% for *B. glabrata* and 0.00025% for *O. hupensis* [11]. The crude oil from *J. curcas* formulated as an emulsifiable concentrate had contact toxicity to corn weevil *Callosobruchus chinensis* and bean weevil *Sitophilus zeamais* and deterred their oviposition on corn and sprayed mung bean. The respective LD_{50} values were determined to be 0.91% and 1.92% [16].

The economic importance of castor include synthesis of cosmetics, plasticizers, lubricants, paints, polymers, resins, textile dying, preservatives, printing inks, lacquers, grease, hydraulic fluids, soaps, oil cloth, laxatives, insecticides, fertilizers, utilization in aircraft and space rockets [9, 6].

2. Materials and Methods
2.1. Sample preparation and Extraction
The jatropha and castor seeds were cleaned, dried, and ground. The oil of each was extracted using n-Hexane as solvent in Soxhlet extraction method [7]. The oil was collected and solvent recovered for further use. The oil was stored in the refrigerator till it was used for further experiments.

2.2. Biopesticidal Value of Castor and Jatropha Seed Oil
Termite (*O. obesus*) and cockroach (*Blattella germanica*) were collected and acclimatized for about 24 hrs. Each batch of insects, held in a rigid polythene container with a mesh lid, was transferred to the test room maintained. An l0 ml plastic beaker containing cotton wool soaked with l0ml water was inverted on the mesh to provide a water source for the insects. Then, modified bioassay method was employed to evaluate the biocidal activity of castor and jatropha oil [9, 10]. Hence, each time oil samples of 1, 2.5, 5 and 10% oil solution in 20% of ethanol were made and 1 mL of the solution was taken in testing Jars/Petridis. Food or water was given during the test period after every count. After the insects had recovered, knockdown counts were recorded every 12 hrs.

2.3. Statistical analyses
The data collected were analyzed statistically using SPSS vers. 16 (SPSS Inc., Chicago, IL, USA) and Origin 6 and excel. One-Way Analysis of Variance (ANOVA) followed by Tukey's Honestly Significant Difference (HSD) for mean comparison between values of the treatment was used. The data obtained was done in triplicates.

3. Results and Discussion
3.1. Oil Extraction and Physicochemical Characterization
The calculated percentage oil/dry weight extracted, using Soxhlet extraction technique and n- Hexane from castor seed was 46% and from jatropha seed was 41%.The physicochemical parameters were with in American Standard Testing Method (ASTM) (Table 1 & Table 2).The results were compared with Pyrethrin Pesticide.

Table 1: Physical Properties of Jatropha Oil vs. Pyrethrin 1

Parameters	*ASTM Specifications (Pyrethrin 1)	Jatropha oil (This study)	Significance
Boiling point	170-230 °C	323	Identification
Melting point	52-55 °C	53	Identification
Solubility in water @ 3pH	insoluble in water	insoluble in water	Less leaching to groundwater strata
Specific Gravity	0.957-0.968@20 °C for 50 %	0.967	Identification
Partitioning coefficient (LogKow)	2.71-5.2	1.97	Less lipophilic
Bioconcentration Factor (BCF)	100-11,000	2	Less bioaccumulation
EC_{50} (72hrs) for 10 % of substance (termite)	0.12 %w/w	0.06 %w/w	Toxic to termite workers
Surface tension (N/m)	0.050-0.053	0.03	Less risk to surface water

Table 2: Physical Properties of Castor Oil vs Pyrethrin

Parameters	ASTM Specifications for (Pyrethrin)	Castor oil (This study)	Significance
Melting point	-5 to -21 °C	-18 °C	Identification
Boiling point	170-230 °C	297	Identification
Solubility in water @ 3pH	insoluble in water	insoluble in water	Less leaching to groundwater strata
Specific Gravity	0.957-0.968@20 °C for 50%	0.967	Identification
BCF	300-11,000	68	Less bioaccumulation
Partitioning coefficient ($LogK_{OW}$)	2.71-5.2	1.15	Less lipophilic, less toxic
EC_{50} (72 hrs.) for 10% of substance(termite)	0.12%w/w	1.43% w/w	Toxic to termite workers
Surface tension (N/m)	0.050-0.053	0.02	Less risk to surface water

Table 3: Chemical Properties of Jatropha Oil vs. Pyrethrin

Parameters	*ASTM Specifications/ Pyrethrin	Jatropha oil	Significance
pH of 10% solution	3 to 9	6.8	Accidental-oral ingestion
Flash Point (°C)	75-112 °C	250 °C	non-flammable
Peroxide Value (Meq/kg of oil)	10.79 ± 1.16	4	non-combustible
Saponification Value [mgKOH/g of Oil]	90 – 105	188	Moderate free fatty acid(FFA) content
Iodine Value [mg I_2 / 100 mg of Oil]	119-120	90.8	Unsaturated=favours biopesticidal potential

Table 4: Chemical Properties of Castor Oil vs. Pyrethrin

Parameters	*ASTM Specifications/ Pyrethrin	Castor Oil (This study)	Significance
pH of 10% solution	3 -9	6.1	Accidental-oral ingestion
Peroxide Value (Meq/kg of oil)	20-23	4.2	Non-flammable
Flash Point	>232 °C	250	Non-flammable
Saponification Value [mg KOH/g of Oil]	90 – 105	181.55	Moderate free fatty acid(FFA) content
Iodine Value [g I_2 /100 g of Oil]	119-120	83	Unsaturated=favours biopesticidal potential

FTIR spectra in KBr pellets were recorded. The IR absorption spectra were measured in the 500-4000 cm^{-1} region. Broad and strong peak centered at 3300 cm^{-1} indicates -O-H functional groups and –C–H, where C is not part of a benzene ring sharp, strong peak on the low side of 3000 cm^{-1}, between about 2850 and 3000 cm^{-1} is –C=O. The Ester functional group was observed at a range of 1715–1750 cm^{-1} which is weak and narrow peak (Figure 1 & Figure 2).

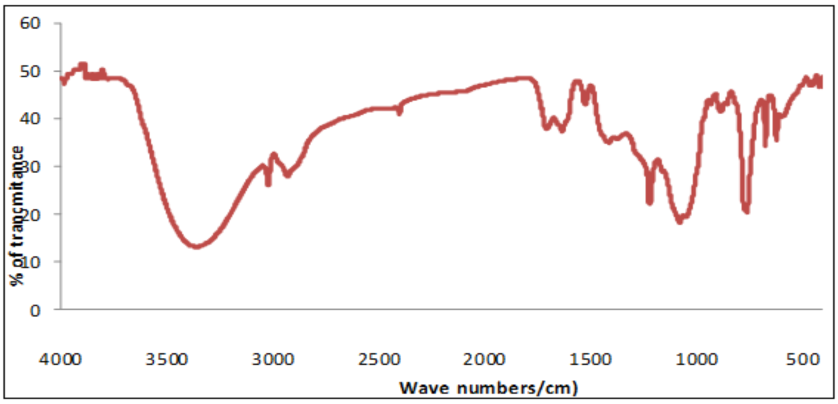

Fig 1: IR Spectrum of Jatropha Oil

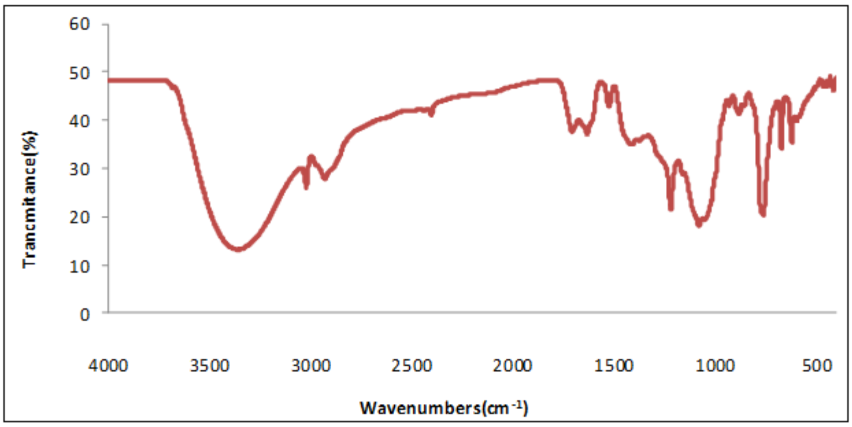

Fig 2: IR Spectrum of Castor Oil

The UV-Vis spectroscopic measurements for the new biopesticide in acetone solution showed characteristic absorption maxima at 290 nm for castor oil. Following same procedure absorption maxima of jatropha oil case study was at 310 nm.

3.2. Biocidal activity of Jatropha and Castor Oils

The results showed that at 10% concentration of jatropha oil, all the termite workers were killed within 48 hrs. and for 10% castor oil at 72 hrs. (Figure 4 and 5). However, jatropha and castor oils concentrations of 1% killed the termite workers in 108hrs and 132 hrs., respectively (Figure 4 and 5). But, in 1% and 10% concentration of jatropha oil, the cockroach workers were killed within 180 hrs. and 72 hrs., respectively and for castor oil in 120 hrs. and 60hrs (Figure 6 and 7). The LD_{50} was determined to be 0.64 % and 1.24% for termite and cockroach, respectively for jatropha oil case (Figure 10). It was determined to be 1.43% and 1.08% for termite and cockroach respectively for castor oil case. The biopesticidal potential of the oil is statistically significant ($p < 0.05$) when compared with blank and solvent controls at all concentration tested. This is in agreement with the findings of [17]. In the case of termites, jatropha oil gave the better result (Figure 8). In case of cockroach castor oil provided better result (Figure 9).

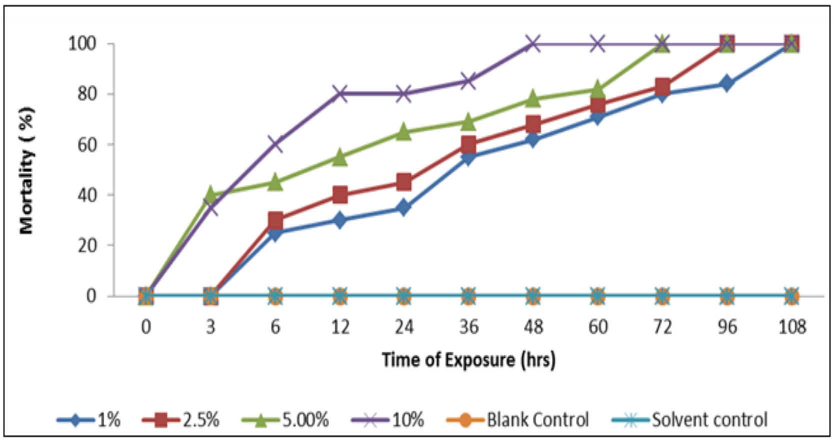

Fig 4: Plot of percentage mortality of termite workers vs. time with different concentration of jatropha seed oil

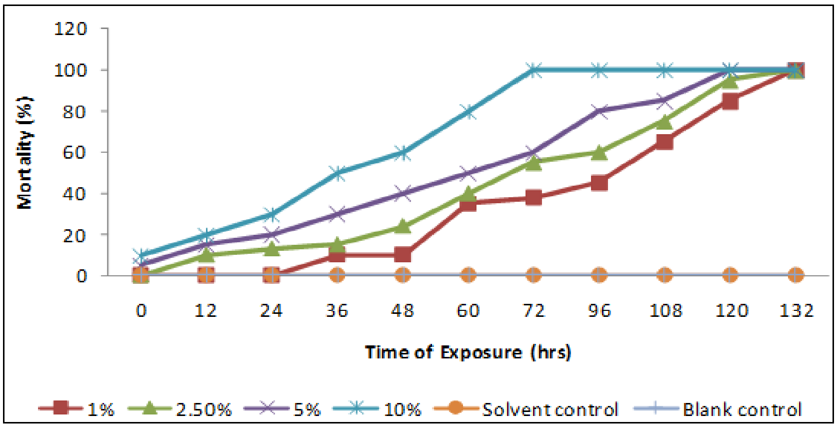

Fig 5: Plot of percentage mortality of termite workers vs. time with different concentration of castor seed oil

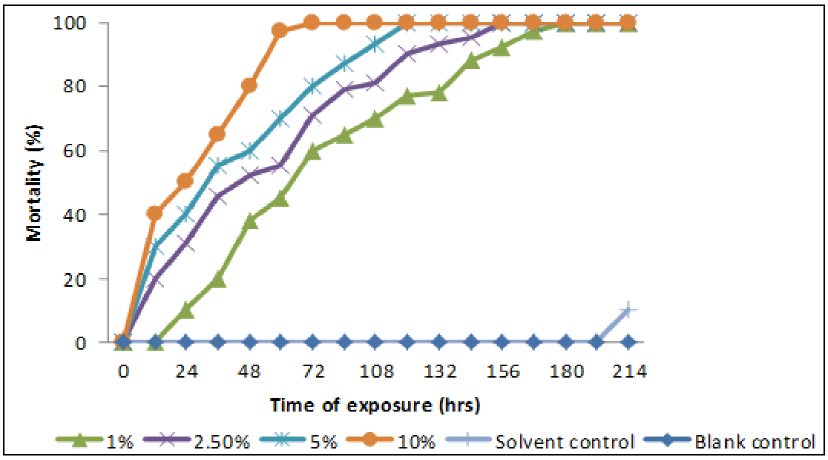

Fig 6: Plot of percentage mortality of Cockroach vs. time with different concentration of jatropha seed oil

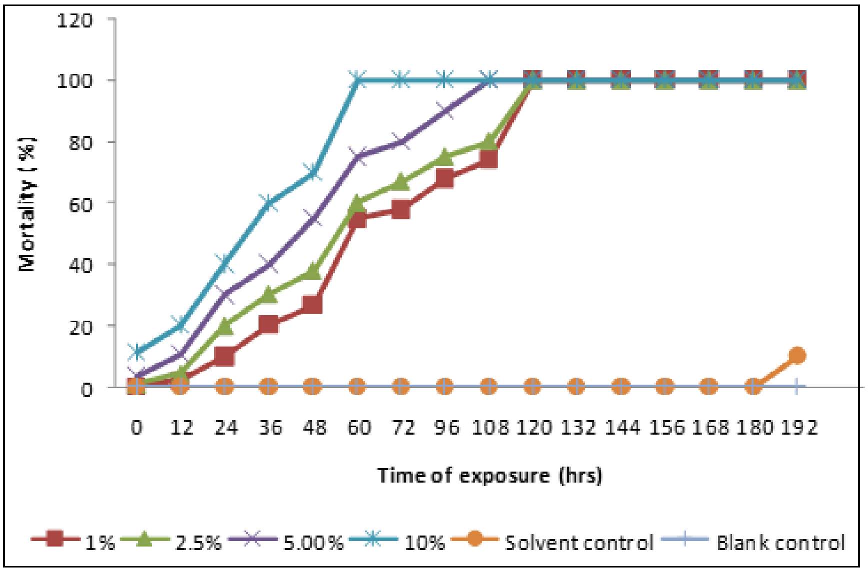

Fig 7: Plot of percentage mortality of Cockroach vs. time with different concentration of castor seed oil

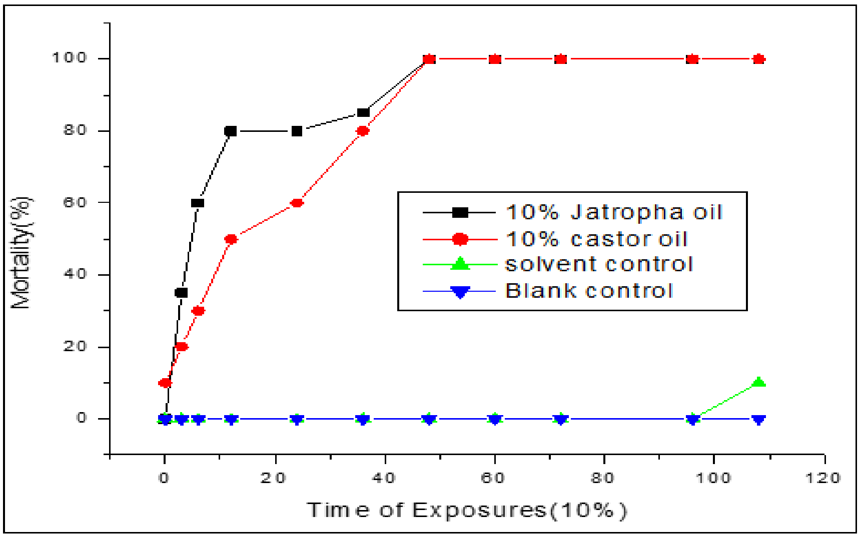

Fig 8: Comparative plot of percentage mortality of termite workers vs. time with 10% of jatropha or castor seed oils

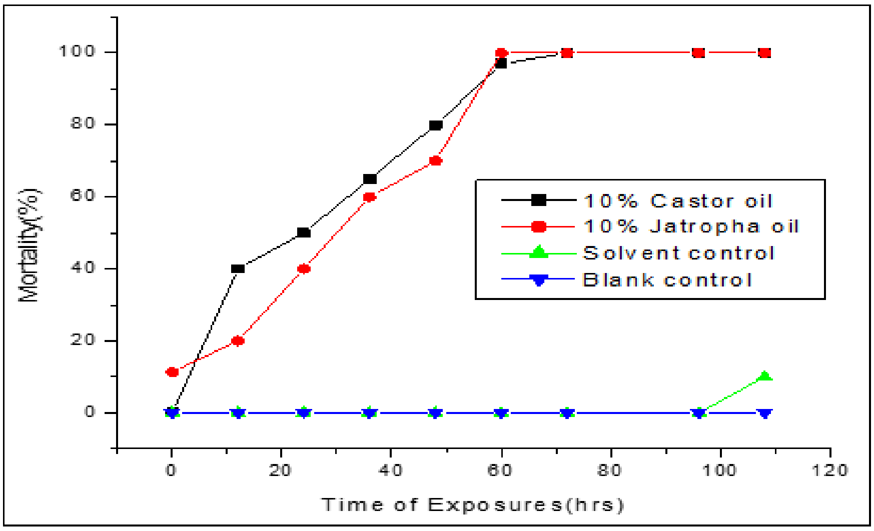

Fig 9: Comparative plot of percentage mortality of cockroach workers vs. time with 10% of jatropha or castor seed oils

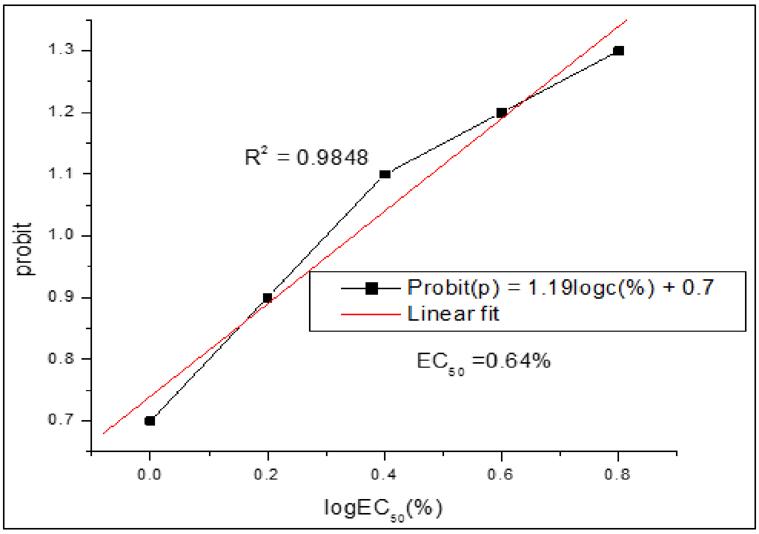

Fig 10: Plot of Probit vs. logc (%) for jatropha oil to termite workers after 72 hrs. exposure

4. Conclusion and Recommendations

From the present study, it can be concluded that oil can be used as an alternative in pest management programs against many pathogens like termites and cockroach. Further studies would still be required for better understanding of especially the chemistry of the biocide using NMR, GC-MS, MS, LC-MS, Elemental analyzer, X-Ray crystallography. The researchers believe that field level studies would be needed to further validate and reproduce their biopesticidal potential.

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