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Insecticidal and Repellency Effects of Smoke from Plant Pellets with or without D-allethrin 90 EC Against Three Medical Insects

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Abstract: Smoke from pellets made from pulverized waste wood, palm-kernel cake, dried "Kuka" (*Adansonia digitata*) leaves and d-allethrin 90 EC, were assayed against adults of *Anopheles gambiae* Giles, (0-3 day-old) *Musca domestica* Linnaeus (0-3 day-old) and *Periplaneta americana* Linnaeus (0-7 day-old) in the laboratory for their toxicity and repellency. The pellets contained 0 g (LPP^0), 0.01 g ($LPP^{0.01}$) and 0.05 g ($LPP^{0.05}$) of d-allethrin, respectively. The time taken for complete combustion increased with reducing amount of d - allethrin in pellets. At the 1.0 g level LPP^0 pellets had significantly higher combustion time (2328.75 sec) relative to $LPP^{0.01}$ (2027.50 sec) and $LPP^{0.05}$ (2029.67 sec) when values were compared by ANOVA and means were ranked by Duncan's Multiple Range Test ($p = 0.05$). All the pellet grades caused mortality of *A. gambiae* and *M. domestica* but not *P. americana*. *Anopheles gambiae* was more susceptible to pellet smoke than other insects. Against *A. gambiae* the Median Lethal Dose (LD_{50}) was 0.47, 0.50 and 0.20 g for LPP^0, $LPP^{0.01}$ and $LPP^{0.05}$, respectively while it was 0.52, 0.46 and 0.46 g for LPP^0, $LPP^{0.01}$ and $LPP^{0.05}$, respectively against *M. domestica*. All the pellets repelled both *A. gambiae* and *M. domestica*. None of the pellet grades gave any repellency against *P. americana*.

Key words: Pellets, d-allethrin, insecticide, repellent, *Anopheles gambiae*, *Musca domestica*, *Periplaneta americana*

Introduction

Synthetic insecticides are widely used for the control of pestilent household insects. These insecticides come with different brand names and are available in various formulations including aerosols, emulsifiable concentrate EC, fumigants, coils etc.

In Nigeria smoke from the burning of insecticidal coils are used to deter insects and prevent them from contact with humans. Such coils and their respective components are among various insecticidal agents imported into Nigeria (Akingbade, 1991). The synthetics are known to be carcinogenic, teratogenic and mutagenic to mammals (Boroffice and Boroffice, 1993). Among the plethora of insecticide groups, it is advised that pyrethroids and other terpenoids be used as insecticides on account of their non-persistence and safety to mammals (Kumar, 1984; Denloye and Makanjuola, 2001; Pates *et al*., 2002).

Locally available natural plant products in Nigeria possess insecticidal properties that can be used in the control of insect pests. These include wood from various trees (Malaka, 1996),

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neem-*Azadirachta indica* (Don Pedro, 1985; Makanjuola, 1989), *Citrus* plants (Don Pedro, 1996) garlic-*Allium satvum* (Denloye *et al*., 2003). Don Pedro (1985) and Malaka (1996) reported that night guards and rural folks in Nigeria burn some of these plants for their smoke that prevents attack by insects. It is therefore possible that plants alone can be burnt and their smoke used to effectively deter insects without the addition of synthetic insecticides.

In the present study we evaluate the insecticidal potency and repellency of smoke from plant pellets with (or without) d-allethrin 90 EC (a synthetic pyrethroid) against mosquitoes (*Anopheles gambiae* Giles), housefly (*Musca domestica* Linnaeus) and cockroach (*Periplaneta americana* Linnaeus) in the laboratory. These are insects of medical importance in Nigeria, against which the insecticidal coils are used.

Periplaneta americana, is so common in Nigeria that it is found in every household (Youdeowei, 1980). It is a nuisance and carrier of pathogens of various diseases including typhoid fever, dysentery, food poisoning, nosocomial infections and other human diseases in homes and hospitals (Agboadze and Owusu, 1989; Fotedar *et al*., 1991; Vythilingam *et al*., 1997; Kim *et al*., 1995). Likewise, *M. domestica* is responsible for the spread of pathogenic microbes such as those responsible for blinding chlamydial infections, cholera, shigellosis and salmonellosis (Fotedar *et al*., 1992). Anopheles mosquitoes are the vectors of malaria, the most important parasitic disease in the tropics, responsible for the death of over one million African children annually (Coetzee, 1997; Egwunyega *et al*., 1995; Teklehaimanot, 2001; Rose, 2001). Anopheles mosquitoes constitute 83.1% of mosquito catches in Lagos (Amajoh *et al*., 2002).

The present evaluation would indicate the possibility of controlling medical insects using coils devoid of d-allethrin.

Materials and Methods

Experimental Pellets

Samples of pellets were supplied by Johnson Wax Nig. Ltd., Isolo, Lagos. The pellets were made from pulverized waste wood, palm-kernel cake, "kuka" (*Adansonia digitata*) leaf and d-allethrin 90 EC, a synthetic pyrethroid. The pellets contained 0, 0.01 and 0.05 g of d-allethrin and were labeled as LPP^0, $LPP^{0.01}$ and $LPP^{0.05}$, respectively. A sub sample of LPP^0 was taken and weighed into 0.25, 0.50, 1.0 and 1.5 g, etc. Sets of each of these weighed pellet samples were obtained. Each of them was, respectively wrapped in aluminum foil and then enclosed in polythene bags. This was in order to prevent loss of activity of the ingredients in experimental pellets. $LPP^{0.01}$ and $LPP^{0.05}$ pellets were treated similarly, respectively. All samples were kept away in cupboards in a refrigerated laboratory room. These samples were used for assays in the present study.

Test Insects

The insects used in these investigations are 0-7 day-old cockroach (*Periplaneta americana* Linnaeus), 0-3 day-old mosquito (*Anopheles gambiae* Giles) and 0-3 day-old housefly (*Musca domestica* Linnaeus). A stock of *P. americana* nymphs was obtained from homesteads and maintained on biscuits with damp cotton wool in corrugated paper packs in the entomology laboratory of Lagos State University (LASU), Lagos, Nigeria until they became adults.

Adults of *Anopheles gambiae* were bred in the laboratory as previously described by Denloye *et al*. (2003). Adult mosquitoes (0-3 day old) from this stock were used in the bioassays.

Musca domestica adults were obtained from homesteads and maintained on raw meat. Larvae produced from this stock were transferred into 1 L Kilner jar and maintained on deteriorating meat until adult emergence. Adults (0-3 day old) from this stock were used in the subsequent bioassay. Prior to bioassays flies were maintained on sugar solution for 24 h.

Assays

Combustion Time

Time taken for selected weight of the three samples of pellets to be completely burnt was estimated in the laboratory. This was achieved by igniting predetermined amount of pellets of known weight on a metal stand. The pellet was transferred into smoke-proof fumigation glass cage upon ignition. Time of ignition and complete combustion were taken respectively using Smith® laboratory stop clocks. These were replicated four times for each pellet admixture. The combustion time would be used to determine the average time of exposure of test insects to grade samples of different amount(s).

Toxicity of Pellets

The toxicity of the smoke of respective pellet samples against each of the three test-insect species were assessed in no-choice bioassays.

For the mosquito bioassay, 10 adult *Anopheles gambiae* were confined to smoke of 0.25, 0.5 and 1.0 g (determined from preliminary studies) of pellets without d-allethrin in respective smoke-proof rectangular glass chambers. A control cage was made containing 10 adult insects but without smoke from burning pellet. The experiment and control were replicated four times in a Randomized Block Design (Bailey, 1995). The number of dead mosquitoes at the end of smoke production by pellet was also taken. This was used to determine mortality in this study. Insects which failed to move any part of their body when touched with the tip of a pair of forceps were taken as dead. The other two pellet admixtures were also each used against the mosquitoes in succession. In the same manner pellet types were assayed, respectively against adult *M. domestica* and *P. americana.*

Repellency

Smoke-proof two-chambered glass cages, each with a door partition separating one chamber form the other, were used for this test. Adult mosquitoes (10) were confined in one chamber where ignited pellet was introduced. The door partition was opened with a door-to-wall gap of 2 cm for exit of insects that desired oriented movement away from pellet smoke into the second chamber. The experiments were replicated four times. In subsequent repellency tests houseflies (*M. domestica*) and cockroaches (*P. americana*) were respectively substituted for mosquitoes. Control experiments were carried out appropriately in repellency tests. All the experiments and checks followed the same pattern as for mosquitoes.

Data Analyses

Results of bioassays were analyzed by probit method following Finney (1971) through which Median Effective Dose (ED_{50}) and the corresponding value of ED_{99} were obtained. Insect mortality due to insecticide stress as different from those arising from other factors was obtained using Abbott (1925) formula. The homogeneity of data from treatment blocks was determined by one-way analysis of variance (ANOVA) in accordance with Randomized Block Design (Bailey, 1995). Means were separated by Duncan's Multiple Range Test.

Results

Combustion Time

There was variation in the mean combustion time of all the pellet admixtures (Table 1). The time taken to effect complete combustion varied with the d-allethrin load of the pellets. Pellets without d-allethrin took longer time to burn completely than those with the pyrethroid. Pellets with the highest d-allethrin load burnt faster than others.

Bioassays

Insecticidal Effects

Different doses of the three pellet admixtures gave varied insecticidal effects against mosquitoes and housefly, but none to the cockroach used in this study. *Anopheles* was more susceptible to pellet smoke than *M. domestica* but marginally less susceptible to pellets with 0.01 g of d-allethrin ($LPP^{0.01}$) (Table 2 and 3). Comparative presentation of the Median Effective Dosages (ED_{50}) of the three pellet types showed that the $LPP^{0.05}$ was remarkably more effective than the other two. Marginal differences were observed in the ED_{50} values of the LPP^{0} and $LPP^{0.01}$. The dose to effectively kill 99.0% (LD_{99}) of mosquitoes (for practical purposes) however shows that the LPP^{0} was more effective, followed by $LPP^{0.01}$ and then $LPP^{0.05}$. Considerable variation was observed when the ED was computed (for practical housefly control). It was shown that with a value of 2.66 g, the $LPP^{0.05}$ pellets were more effective than LPP^{0} and $LPP^{0.01}$ against the housefly. The $LPP^{0.01}$ was the least effective against the housefly.

When the different pellets were used against the cockroach, no mortality was observed up to 2.0 g of each of the grades of pellet. Comparison with the checks however showed that the insects exposed to pellet smoke in each of the three cases initially became restive, moved about randomly in wavy, irregular patterns but subsequently stayed relatively inactive in the corners of the fumigation

Table 1: Combustion time of three grades of pellets

	Mean combustion time (sec)*		
Grade	0.25 g	0.5 g	1.0 g
LPP^{0}	513.50	1107.5	2328.75^{a}
$LPP^{0.01}$	401.25	891.5	2027.50^{b}
$LPP^{0.05}$	470.00	567.4	2029.67^{b}

* Each mean datum is from 4 replicates; Data carrying the same letter (s) are not statistically different by Duncan's Multiple Range test (p = 0.05)

Table 2: Percent mortality of *Anopheles gambiae* (An), *Musca domestica* (Mu) and *Periplaneta americana* (Pe) confined to smoke of pellets

	Percent mortality								
	LPP^{0}			$LPP^{0.01}$			$LPP^{0.05}$		
Dose (g)	An	Mu	Pe	An	Mu	Pe	An	Mu	Pe
0	2.50^{a}	5.00^{a}	0	2.50^{a}	5.00^{a}	0	2.50^{a}	5.00^{a}	0
0.25	2.50^{a}	22.50^{a}	0	22.50^{a,b}	35.00^{b}	0	45.00^{b}	32.50^{b}	0
0.50	22.50^{ab}	50.00^{b}	0	35.00^{b}	47.50^{b}	0	72.50^{c}	70.00^{c}	0
1.00	35.00^{b}	80.00^{b}	0	90.00^{c}	80.00^{c}	0	90.00^{c}	85.00^{c}	0

Each datum is a mean of four replicates; Means in the same column accompanied by the same letter (s) are not significantly different by Duncan's Multiple Range Test (p = 0.05)

Table 3: Effective dosages of LPP^0, $LPP^{0.01}$, $LPP^{0.05}$ pellets for mortality of *Anopheles gambiae* and *Musca domestica*

	Pellet admixtures					
	LPP^0		$LPP^{0.01}$		$LPP^{0.05}$	
Insects	ED_{50} (g)	ED_{99} (g)	ED_{50} (g)	ED_{99} (g)	ED_{50} (g)	ED_{99} (g)
Anopheles	0.47	2.03	0.50	2.32	0.20	2.75
Musca	0.52	3.46	0.46	5.97	0.46	2.66

Table 4: Percent *Anopheles gambiae* (An), *Musca domestica* (Mu) and *Periplaneta americana* (Pe) repelled by smoke from pellets

	Percent insects repelled								
	LPP^0			$LPP^{0.01}$			$LPP^{0.05}$		
Dose (g)	An	Mu	Pe	An	Mu	Pe	An	Mu	Pe
0	0	0	0	0	0	0	0	0	0
0.25	15.00	10.00	0	100	100	0	100	100	0
0.50	37.50	35.00	0	100	100	0	100	100	0
1.00	37.50	37.50	0	100	100	0	100	100	0

Each datum is a mean of four replicates

chamber. The 0.25 and 0.5 g of the three grades did no elicit this behaviour. All insects in the fumigation chamber regained their normal activeness within 10 min after the exit doors in the chambers were opened.

Repellency

The smoke from pellet repelled *A. gambiae* and *M. domestica* but not *P. americana*. When Anopheles was used at the 0.25 g dosage level, the LPP^0 did not show appreciable repellency relative to the control. The $LPP^{0.01}$ and $LPP^{0.05}$ pellets gave 100% repellency; all the insects flew out of the chamber (with burning pellets) into the second one. Similar observations were made for *M. domestica* (Table 4).

Discussion

The present study has shown that the presence of d-allethrin as part of the admixture in pellets enhanced the rate of combustion. In effect, this may mean quicker availability of insecticidal active ingredient (a. I) in smoke to the target insect.

All pellet used here demonstrated toxicity to both housefly and mosquito. This is an indication that the plant materials in pellets without d-allethrin (LPP^0) have insecticidal properties. It is estimated that there 250,000 species of plants today (Benner, 1993) and that many of them act as leads for chemical syntheses of commercial insecticides (Gilmour, 1978). The presence of components noxious to insects in the plants used in formulating the pellet is therefore indicated in the present study. One of the plants is *Adansonia digitata,* the others are palm kernel (*Eileas guinensis*) cake and miscellaneous wood shavings (unidentified). There is need to isolate and identify the components of these wood shavings with a view to specifically determining their respective insecticidal potentials.

The d-allethrin load in the pellet used had a positive effect on the toxicity of smoke to mosquitoes and housefly in this study. This is consonant with the established insecticidal efficacy of pyrethrum products (Kumar, 1984; Cremlyn, 1978; Thijssen, 1997).

The differential susceptibility of insects to chemicals is further demonstrated here. The mosquitoes were generally more susceptible than any of the other insects used. This may be due to the fragility and high sensitivity of the insect. Also cockroach is larger in size than either mosquito or housefly (Walker, 1994). The lack of efficacy of pellet smoke observed for cockroaches may also be due either to the mode of availability of insecticidal a.i or the absence of chemicals noxious enough to produce toxicity or repellency in cockroaches. Studies have shown that other plants such as *Azadirachta indica* (neem) when administered to cockroaches adversely affected growth and development of the insects (Richter *et al*., 1997). This, therefore opens another vista for studies on the efficacy of plant products for insect control.

The present study has demonstrated that the pellets used were effective as insecticides and repellents against mosquitoes and housefly, even when they were devoid of the synthetic pyrethroid (d-allethrin). The use of repellents and insecticides is a sure way of avoiding mosquito bites (Phillip and Bialek, 2002) and contact with other insect vectors. Hence these findings should have good use in the production of insecticidal and insect repellent coils.

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