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Research article

POTENTIAL OF NEEM PLANT PRODUCTS (Azadirachta Indica A. Juss Synomym Melia azadirachta) AS A PROTECTANT AGAINST ADULT MORTALITY, RATE OF OVIPOSITION AND EMRGENCE OF F_1 GENERATION (ADULT) OF Dermestes maculatus Degeer ON DRIED FISH.

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Abstract

This study investigated the potential of Neem plant products namely Neem Kernel Oil (NKO), Neem Kernel Powder (NKP) and Neem Leaf Powder (NLP) as a protectant against dermestid beetles (*Dermestes maculatus* Deg.) on dried fish were evaluated. NKO at the rate of 1ml/35g of dried fish was found to induce higher mortalities of the adult insect than NKP and NLP, and this was significantly different at (p=0.01). However, there was no significant difference on the level of adult mortalities induced by NKP and NLp at the rate of 5g/35g dried fish respectively. The rate of oviposition of the insect was drastically suppressed by both NKO and NKP at the rates of 1ml and 5g per 35g of dried fish than NLP at the rate of 5g/35g of dried fish, and this was significantly high statistically at (p=0.05). although, the cumulative oviposition rate following 28days post treatment application (PTA) between the treatments shows no significant difference from the analysis of variance (ANOVA), but the control resulted in a higher rate of oviposition that was significantly different at (p=0.05) from NKO and NKP, but similar statistically to NLP. There were no emergence of F_1 generation of *Dermestes maculatus* in all the three treatments, and no significant difference exists statistically between the various Neem plant products after 12 weeks of post treatment application (WPTA). Therefore, ass the treatments suppressed the emergence of F_1 generation of *Dermestes maculatus* over the control. The palatability (organoleptic) of the treated fishes was also determined, with only NKO found not to have post treatment residual effect on the dried fishes after cooking and eating by selected respondents. The result is indicative of the potential of NKO as a protectant against dermestid beetle adults, rate of oviposition and emergence of F_1 generation of the insect on dried fish.

KEYWORDS: *Dermestes maculatus*, Neem Kernel Oil (NKO), Neem Kernel Powder (NKP), Neem Leaf Powder (NLP), F_1 generation, Oviposition rate,

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Introduction

Dried fish is an important component of diet for many people throughout the world. The total world production has risen from about 20 million tonnes in 1938 to more than 73 million tonnes in 1976 (Clucas and Sutcliffe, 1981). The per capital consumption of fish for human food in the 70's was 11.8kg, a figure which varies considerably from country to country. Rollings and Hayward (1963) estimated the dried fish trade in the Lake Chad area of Nigeria at £3 million annually. Consequently the dried fish traffic has far exceeded all predictions. Figures obtained from fish traffic census at Maiduguri, North-Eastern State of Nigeria showed that dried fish production rose from 6.4 million kilograms in 1969 to 26.5 million kilograms in 1971, valued at £3.2 million (₦6.4 million) and £12.7 million (₦25.48 million) respectively at the source (Osuji, 1976). Green (1967) reported that the dried fish trade is the largest of the very few natural industries which Aden possesses. It is generally estimated that the value of exported dried fish is about £200,000 to £300,000 annually and that between 8 and 10 million are engaged as fishermen and that probably an equal number are employed in service industries to the primary producers as traders, processors, mongers etc. thus creating different employment opportunities, and a great source of income.

Dried fish is a very important item in West African diets, and the reasons for this are many and varied. The main one, however, is that dried fish is rich in protein, a nutrient essential for health and growth of the body. Twenty percent (20%) of the weight of fish flesh is protein. Dried fish is a highly favoured item of many traditional dishes; it greatly enriches their flavor and enhances the nutritional status of the dishes by furnishing excellent quality but inexpensive proteins and often a good alternative to fresh fish which in many places is not really available 9Osuji, 1976). Dried fish proteins compares favourably with egg, milk and meat in its amino acid composition and, in fact, often has higher levels of essential lysine and methionine both of which are lacking in cereal-based diet. The loss of water during fish drying results in an apparent increase in the concentration of its nutritionally important constituents and a greater nutritional value for the weight of fish purchased. Fat is the other major nutrient supplied by dried fish and they contain 20% or more of this in their flesh. This fact is characteristically high in poly-unsaturated fatty acids (PUFAS) making them important in diets for people requiring to keep low levels of cholesterol in their blood. The smoking of this fish confers definite bactericidal characters and also protects the fish constituents, especially fish lipids from oxidation. Dried fish is also a ready source of energy which is valuable in areas where the overall calorie per head is insufficient. Dried fish oils contain fairly high quantities of vitamins especially A, D, thiamin, riboflavin, nicotinic acid and B_{12} making them more important in Vitamin deficient diets. They are also rich in mineral constituents. Present are calcium and phosphorus in bones, iron in liver, magnesium, copper, which are important trace elements. However, dried or smoked fish have higher keeping quality than fresh one, and it increases the varieties in which it can be presented. The release of special flavours and aromas when smoked improves the general acceptability of dried fish, and it has the special advantage over fresh fish in being ready for consumption without further cooking.

However, the main constraint with dried fish production is infestation by the dermestid beetle (*Dermestes maculatus* Deg.) during processing, storage, transportation as well as the marketing stage of dried fish (Osuji, 1974). Large scale deterioration in quality and losses in quality of processed fish results from insect infestation as well as from other physical and biological agencies. Such losses in edible material may be considered very significant nutritionally (Cutting, 1961). As with all food materials stored in the tropics, certain precautions must be taken in order to maintain product quality. In the case of cured fish, the major problems are insects, mites, rodent infestation, mould growth and halophilic bacterial contamination. Cured fish will keep for some time if they are kept in dry conditions, free from attack by rodents or infestation by insects. Under the hot and generally humid conditions of the tropics, dried fish are prone to infestation by certain insect species and mites which can cause considerable losses. Estimates of quantities of fish to damages by insect pests to be marketed, are sometimes put as high as 50% with financial losses correspondingly heavy 9Rollings and Hayward 1962, Aref et al, 1964). Ther are many types of insects which affect fish quality. These include the Blow flies, *Dermestes maculatus. Necrobia rufipes, Trogoderma granarium,* and *Tribolium castaneum*. The most significant of them being *dermests maculatus* and Blow flies. The species of Blow flies that are capable of breeding on fish include *Chrysomyia marginalis* Wied. (Proctor, 1972), *Carpophilus dimidiatus* (F) and *Wohlfartia Spp.* (Green, 1967). *Dermestes maculatus* Degeer is the most important insect pest of dried fish. *D.frischii* Kug. Has been reported as the main pest of dried marine fish in South Arabia (Green, 1967) but records from else where indicate that *D. Maculatus* is the most frequently encountered pest 9Proctor, 1972), *D. frischii* is normally found to infest marine fish while *D ater* is found occasionally on dried fish but appears to be relatively minor pest of the product (Green, 1967, Proctor, 1972).

In Nigeria, *D. maculatus* is generally associated with dried fish, especially during its storage, transportation and marketing stages (Osuji 1973). The species is also associated with dried meat. In a provisional list of insect infesting various commodities in Nigeria, *D. maculatus* have been recorded as a major pest of dried fish, Rollings and Hayward (1962) estimated annual losses due to *D. maculatus* damages to dried fish at about £500.000 (₦1,000,000), and predicted proportionally greater losses when the dried fish trade in Nigeria achieved its potential growth rate. In contrast to the problems of dried fish infestation in Nigeria with respect to *D. maculatus,* a closely related species *D. frischii* has been the subject of intensive biological experimentation aimed at the ultimate control of the pest. (Green, 1967, Amos, 1968). Osuji, (1974) reported in a survey of infestation in Ibadan market, Nigeria, that a high proportion of the dried fish sold in the market harboured beetle infestation and mainly *D. maculatus* Deg. and *N. rufipes* Deg. *D. maculatus* was the dominant pest, accounting for about 71.5% of the observed infestation. These beetles will generally select fish with a lowere moisture content in the range of 15 – 30%, but they are typically inhibited by moistures greater than 45% (FAO, 1981), but occasionally can ne found on fish with a moisture content as high as 50%. The longer dried fish are stored, the greater are the losses to beetle infestation. These insects will feed and reproduce on dried fish finally reducing it to a powder of waste products. Infestation of dried fish by the dermestid beetle (*D. maculatus*) commences in the fish producing areas, where female adults of the beetle lay their eggs on the drying fish usually spread out on mats on the ground (Osuji, 1974). Most of the damages done to dried fish by the beetle has usually been attributed to the larvae of this beetle (Aref et al, 1964). The damages caused to dried fish by this larvae is due to their voracious feeding activity and boring of the edible portion of the dried fish by the late instar larvae, during a normal period of storage, thus reducing the fish to mere frass and bones within weeks. This will ultimately result in loss in weight and reduction in nutritional value of the fish (Cutting 1961). The fish are often rendered unfit for human consumption because of contamination with faeces and larval exuviae, and aesthetically unacceptable to prospective buyers. Loss in fish weight in the range of 43.0% and 62.7% had occurred respectively as a result of damages by dermestid beetle larvae (Osuji, 1974). When assessing the loci of infestation by this beetle, Osuji, (1974) reported that adults and late instar larvae of *D. maculatus* were usually located in various bones in the head capsule and in the eye sockets. Early instar larvae were usually found in muscular tissues in the body wall of the fish. Most of the pupae and pre-pupae of *D. maculatus* were observed in tunnels within thick muscle blocks of dried fish. The concentration of the pest in these loci may be concealment of the individuals as well as availability of essential nutrients. For the adults and advanced instar larvae, concealment would be provided within the bones of the head and vertebrae, where as the muscle blocks would furnish lipids and protein dietary requirement for the growing larvae instars (Osuji, 1973). With respect to *D. maculatus*, seasonal fluctuations in the abundance are widespread. The development of the pest species depends indirectly on changing environmental conditions and the immediate micro-climate of the dried fish itself. The peak abundance of the pests is normally in the warm dry months of the year (Jan – May and Oct – Dec) while the lowest densities is generally during the wet and cool months 9June – Sept). According to Osuji (1973), in a survey carried out from the Dugbe market, South – West of Nigeria, the highest density of *D. maculatus* was recorded in the months of January – May and October to December 1971, while in 1972, the months of highest abundance were January, March and May. Lowest values were observed in the months of June – September in 1971 and in June – July in 1972.

However, successful methods of controlling insect pests of drying and dried fish have been developed but their adoption is far from widespread. The main difficulty is that, the greater part of the fish industry in tropical countries is conducted by small traders under relatively primitive conditions, often in remote places. The extension of new techniques in such circumstances presents formidable problems, not the least of which are the lack of trained personnel to pass on information and the reluctance of many people to adopt new ideas. With respect to *D. maculatus*, experiments by previous workers were centered on laboratory investigation of insecticidal treatments on the beetle, and the possible application of the results of such investigations to hides and skins, and similar commodities normally affected by *D. maculatus* (Osuji, 1974). So far, the only insecticides which have been successfully introduced for the treatment of dried fish have been based on pyrethrins synergized with Piperonyl butoxide (Proctor, 1976). This is a dust formulation containing 0.15% w/w pyrethrins and 2.4%w/w piperony butoxide, primarily intended for the production of stored grain, has given three to four months protection from dermestid infestation when applied directly on dried fish. Treatments of *D. maculatus* with organophosphorus insecticides such as Malathion, Malaoxon, Diethylmalathion and Counaphos have been used (Proctor, 1972). But considerable natural tolerance by *D. maculatus* for Malathion and Malaoxon were observed. Application of contact insecticides to larvae of *D. maculatus* and *D. lardarius* showed that they were less readily killed by widely used insecticides than were many other stored products beetles. Proctor (1972) applied Pyrethrum dusts to dried fish and observed some measure of protection against *D. maculatus*, but he pointed out that such insecticidal treatment subsequently rendered the fish aesthetically unattractive to consumers. It is only 3-pyrethrum, Lindane and Malathion that may be applied to food stuffs, but *D. maculatus* is known to be resistant to Lindane. Some silica-based dusts have been used in treating dried fish, and it was found that *N.rufipes* was more susceptible than *D. maculatus* (Aref et al 1965). He tried sulphur dipping and fuming with poor results. Amorphous silica-based dusts, which are virtually non-toxic to mammals have been tried on dried fish (Green, 1967, Proctor, 1972), but were found to be ineffective because they absorbed oil from the fish. Kordyl (1976) applied Faru-tox emulsion to control flies and other insects in dried Sardines from Lake Tanganyika, and he observed that on long term control of insects, particularly the Dermestes Spp, Faru-tox proved to be effective for 4 to 6 weeks, but after 4 months, the materials were heavily infested. Alternatively, insecticides have also been applied to containers used for the storage and transportation of dried fish or to places in which fishes are handled. Osuji (1974) suggested that treatments of jute bags and crates used in transporting dried fish with insecticides or suitable fumigant mixtures such as ethylene dichloride or carbon tetrachloride before use. Application of 20% lindane to the ground beneath fish drying racks controlled blow fly populations. The use of trichlorphon for the same purpose has been recommended. Proctor (1972) recommended regular spraying of internal surfaces of wave house or fogging with contact insecticide or fumigation under a gas-proof sheet. However, Proctor (1976) found that dermestid beetles penetrated sacks treated with a dust formulation of synergized Pyrethrins and infested the contents. Golob *et al* (1987) observed that dried Tilapia spp dipped for 4seconds in different insecticide dips and Deltamethrin (2.5%EC) offers protectim against dermestid infestation for 6months.

The possibilities of insecticidal resistance in *D. maculatus* reported by various workers, and that reported by Proctor (1972) regarding the appearance of insecticides treated fish is of particular relevance to consumers. In view of the hazards to the health of man and domestic animals, these observed short comings have emphasized the importance of physical methods for protecting foodstuff from insect pests (Osuji, 1974). The physical methods have not always yielded the spectacular results which we are accustomed to expect from chemical insecticides. The use of ionizing radiation of up to 10-30 Krad shortened the life span of *D.* maculatus larvae, pupae and adults, and no offspring resulted subsequently (Watters, 1972). Gamma radiation of up to 6-16 Krad was found to have a deleterious effect on the eggs, larvae, pupae with adults been sterile throughout their life (Shokoohian, 1977). Aref *et al* (1964) when investigating the possibility of controlling dermestid beetles in dried fish by means of ionizing radiation, found 53, 000 to 105,000 rad to be lethal to adults, with 23, 000 rad not killing but probably induced sterilization. However, the capal cost of installing irradiation equipment, and the time interval (four weeks or more) between treatment and insect death are obvious disadvantages in Nigeria conditions (Osuji, 1974).

A combined physical and chemical treatment for the long term control of insects in dried fish has been recommended. Toye (1970) suggested the heating of dried fish in simple charcoal fired ovens for 30minutes at four day intervals during the storage period to control infestation. Osuji (1974) recommended that effective dehydration of fish (to about 8% MC) would create a condition that is unfavourable to beetle development and survival. He also suggested that for effective pest control, warehouses should be of concrete block construction with smoothly plastered walls which can be effectively cleaned periodically. Artificial heating of fish above 65-70^{0}C may scorching and spoil the colour or flavor of dried fish, and the range of temperatures available for killing pests without spoiling fish, is therefore, very narrow and the warm smoking technique (45-60^{0}C for 4-7hours) is probably the best method to adopt (Osuji, 1973). Keshvani (1964) observed that well dried fish could be stored for up to one year in sealed polyethylene bags without serious loss of quality. Osuji (1974) recommended the linings of jute bags and crates used for carrying dried fish with polythene sheets and thick brown paper to provide a mechanical barrier against the beetle especially instar lavae of *D. maculatus* and *N. rufipes,* reduced cross infestation as well as possible uptake of moisture in a humid atmosphere.

The choice of a chemical to control pests without causing health hazards is of a great importance. This could possibly be achieved by using the extracts of plants having pesticidal properties; such extracts are comparatively more economical, safer, less toxic and biodegradable (Banerji *et al* 1982). Though certain plants possessing insecticidal properties have been identified, but very little information on the antifeedants properties is available

(Sandhu and Singh, 1975; Pandey *et al* 1977). Various plants products with repellant effect on insects have been shown to afford protection to stored pulses against bean weevil (Pandey *et al* 1977).

Neem tree products (Azadirachta indica: Meliaceae A. Juss synonym: Melia azadirachta) shows consider able potentials for controlling pest of stored products. Three feeding inhibiting triterpenoids have been isolated and identified from Neem kernels (Butter worth and Morgan, 1968). These compounds are Meliantriol, Salanin and Azadirachtin. These Neem extracts have been found to affect more than 200 insect species (Warthen, 1989; NRC, 1992) including the number of stored product pests. The extracts act on different insect species in various ways including repelling adults and larvae distrupting developmental processes inducing adult sterility and disturbing adult behaviour (Warthen, 1989). This is one of the oldest uses in Asia (Jotwani and Sircar, 1967). In traditional practices, Neem leaves are mixed with grain kept in storage for 3-6months. For instance, treatment of jute sacks with Neem oil or Neem extracts prevent pests in particular weevils (Sitophilus spp) and flower beetles (Tribolium spp) from penetrating for several months (Cobbinah and Appiah-Kwarteng, 1989). Neem has also been used to protect stored roots as well as tubers against the potato moth. Similarly, Neem leaf or seed powder mixed with stored maize have effectively reduced the progeny production of Sitophilus oryzae and S. zeamais by distrupting the larval development and adult fecundity (Pereira and Wohlygemut, 1982). Also dry ground Neem seed have been shown to reduce fecundity, prolong pre-imaginal developmental period and considerably reduces emergence of progeny (Ivbijaro, 1983), but adults are rarely affected. Powdered root bark of Zanthoxylum zanthoxyloides (Lam) (Fagara) and seed of Azadirachta indica A. Juss at the rate of 2.5% of the treated seed weight were found to be toxic to the cowpea seed bruchid Callosobruchus maculatus (F) with consequent reduction in loss in seed weight of 55-93% by A. indica and 83-85% with Z. zanthoxyloides after three month of storage (Ogunwolu and Idowu, 1994). Wheat seed has also been protected against S. oryzae, Rhyzopertha dominica and Trogoderma granarium for nearly a year when mixed with powder Neem seed Kernel at 1% or 2% weight of seeds (Jotwanic and Sircar, 1965). Seeds of Mung, Bengal grain, cowpeas and peas can be effectively protected from damage by the bruchid (C. maculatus) by mixing the seed with crushed Neem seed at 1% or 2% of the seeds weight (Jotwani and Sircar, 1967). The germination of the treated seeds was not impaired and organoleptic test carried out after washing and cooking of the seeds showed that they were devoid of taste and odour. Sowunmi and Akinnusi (1983) reported that powdered Neem seed kernel at 1% and 2% mixed with maize and cowpea seeds gave good protection against S. zeamais and C. maculatus for 8months as compared to 89% damage in the untreated seeds. Powdered drupes of Dharek, Neem seeds and Costus roots as well as magnesium carbonate were tested as protectants of wheat seed against attack of Trogoderma grubs; with Neem seed powdered offering the best protection from Khara grubs at 1% or 2% for about 8months (Saramma and Verma, 1971). Neem oil is an extremely effective and cheap protection for stored beans, cowpeas and other legumes. It keeps them free of bruchid-beetle infestations for at least six months regardless of whether the beans were infested before treatment or not . Pereira (1983); found that Neem kernel oil at 8ml/kg cowpea seed gave good protection for up to three month against the cowpea beetle by reducing oviposition. Don-pedro (1985) has established that powdered sun dried citrus peels at higher doses reduced infestation of dried Clarias sp by D. maculatus. Studies by several authors has also shown that various dosages of different types of oil extracted from different plant materials gives complete protection against different storage insect pests (Schoonhoven, 1978, Boughdad *et al*, 1987, Shikaan and Uvah, 1991). Chenopodium ambrosiodes has been shown to be a promising control agent against stored produce insect pests (Delobel & Malonga, 1987).

However, attempts have been made by several workers to control this beetle, and this has largely been based on the use of synthetic chemicals with its associated environmental and health hazards, high cost of purchase, lack of operational skills as well as the resistance of the beetle to some of these chemicals (Aref *et al* 1965; Green, 1970; Proctor, 1972). Other method such as physical method that have proved effective in preserving both the quality and quantity of the dried fish, is also not within the reach of local processors because of high initial capital cost and the high level of technology involved (Osuji, 1974). All these short comings thus necessitates efforts towards identifying, sourcing and testing of plant materials of local origin that are within the reach of local fish processors, non-hazardous to human and animal health, require low application technology and environmentally friendly.

Hence, this study was initiated to evaluate the potentials of some Neem plant products as a protectant against Dermestes maculatus vis-a-vis the effect of the products on adults' mortality, rate of oviposition and emergence of F_1 generation of the insect on treated dried fish with a view to device a control during storage, distribution and marketing of the dried fish.

Materials and Methods

The study was carried out at the storage entomology laboratory of the Department of Crop protection, institute for Agricultural Research, (IAR/ABU) samaru, (11^0 11^1N and $07^0 38^1$E) Zaria, Nigeria. Medium-size dried fishes variety cat fish (Clarias sp) were purchased from Sabon-Gari market (11^0 13^1N and 07^0S2^1E), Zaria, and the Neem products were obtained from the pure-line Neem trees from the premises of I.A.R/ABU, samaru, Kilner jars, Electric oven, weighing balance, basin, Camel hair brush, pipette, fish cutter, forcep, mortal and pestle, teneral adults of *D. maculatus.* The population of the test insect for the study was obtained from the infested dried fish from the market, and sub-cultured in the laboratory using dried fish media at 25-27^0C ambient temperature and 60-75% relative humidity for Six weeks in order to have enough test insects.

Neem Kernel oil (NKO) was obtained by air-drying the collected Neem seeds which were then decorticated to separate the kernel from the seed coat. The decorticated kernels were then grinded and boiled in water to form paste which was the squeezed with the aid of a cheese cloth to extract the oil.

Neem kernel powder (NKP) was obtained by air-drying decorticated kernels which were then grinded with the aid of pestle and mortar, and it was then thoroughly sieved with a fine-mesh sieve.

Neem leaf Powder (NLP) was obtained by air-drying Neem leaf which were later grinded into fine powder with the aid of a mortar and pestle using a fine-mesh sieve.

Experimental Design and Treatments

Twelve medium-size dried fishes weighing 35g averagely were disinfested in an electric oven set at 50^0C for 2-3hrs. The Neem products (NKO, NKP and NLP) were weighed into a lot of 1ml, 5g and 5g respectively. The disinfested dried fishes were cut opened longitudinally with the aid of a fish cutter before applying the pre-weighed Neem products to enable for proper monitoring of the insect activities. Then, on to each cut-opened fish, the Neem products were applied with the aid of camel-hair brush. The treated fishes were then put in the jars and allowed to settle for 5minutes, then, based on the presence of a shallow pit at the centre of the 4^{th} abdominal stermite and the shape of the genitalia (Osuji, 1985, Haines, 1991), the test insect were sexed and two pairs of the teneral adults of *D. maculatus* (Osuji, 1973) obtained from the laboratory culture were introduced into each jar. The jars were then covered with perforated plastic caps lined with muslin cloth to prevent the escape of the test insect and to allow free passage of air into the jars regularly. The entire experiment, consisting of three treatments plus a control and replicated three times, were arranged in a completely randomized design (CRD) on the laboratory table at a temperature which fluctuated between 25 and 27^0C, and 60 and 75% RH. The content of the jars were examined at 24, 48, 72, and 96 hours to assess adult mortality, and this was further repeated at 7, 14, 21 and 28 days post treatment application (PTA). The rate of oviposition by the insect was also assessed at 7, 14, 21 and 28 days PTA. The level of emergence of F_1 generation of the insect was determined at 4, 8, and 12 weeks PTA.

All data obtained were transferred using square root of transformation formular as described by steel and torrie (1980), with an 0.5 as a constant.

i.e. SQT= $\sqrt{X_1 + 0.5} = X_2$

Where,

X_1 = Initials data or value.

X_2 = Transformed data or value

0.5 = a constant

And the data obtained were statistically analysed using analysis of variance (ANOVA) and the mean of the treatments were separated using least significant difference (LSD) at both 1% and 5% level of significance i.e. (P=0.01) and (P=0.05) respectively.

Palatability test was carried out on the treated dried fishes after 12 weeks of the study to determine if there would be any post-treatment residual effect on the taste and odour of the dried fishes after cooking without onion.

Result and Discussion

TABLE I: EFFECT OF NEEM PLANT PRODUCTS ON ADULT MORTALITY OF *Dermestes maculatus* Deg. ON DRIED FISH AT 24 HOUR INTERVAL.

		Mean of Dead Larvae Per Observation				
TREATMENTS		Hours Post Treatment Application (HPTA)				
Neem Plant Products	Rate/35g Dried Fish	24	48	72	96	Cumulative Mean
Neem Kernel Oil (NKO)	1ml	0.88	1.64a	1.00	0.88	4.40a
Neem Kernel Powder (NKP)	5g	0.71	0.71b	0.88	1.18	3.48b
Neem Leaf Powder (NLP)	5g	0.71	0.71b	0.88	0.71	3.01b
Control		0.71	0.71b	1.06	1.00	3.48b
SED±		0.12	0.18	0.29	0.41	0.34
LSD		0.28	0.42	0.67	0.95	0.78
SIGNIFICANCE	NS	NS	**	NS	NS	*

Mean followed with the same alphabet on the same column d o not differ statistically.
* Significant Difference at (P= 0.05)
** Significant Difference at (P = 0.01)
SED = Standard Error Difference
LSD = Least Significant Difference
NS = Not Significant

TABLE II: EFFECT OF NEEM PLANT PRODUCTS ON ADULT MORTALITY OF *Dermestes maculatus* Deg. ON DRIED FISH AT 7 DAYS INTERVAL.

		Mean of Dead Larvae Per Observation				
TREATMENTS		Days Post Treatment Application (DPTA)				
Neem Plant Products	Rate/35g Dried Fish	7	14	21	28	Cumulative Mean
Neem Kernel Oil (NKO)	1ml	2.12a	0.71	0.71	0.71	4.25
Neem Kernel Powder (NKP)	5g	1.95ab	1.06	0.71	0.71	4.43
Neem Leaf Powder (NLP)	5g	0.88c	1.17	0.88	1.06	3.99
Control		1.53b	0.71	1.06	0.88	4.18
SED±		0.25	0.22	0.16	0.16	0.20
LSD		0.58	0.51	0.37	0.37	0.46
SIGNIFICANCE	NS	**	NS	NS	NS	NS

Table I and II shows the mortality of adult *D. maculatus* recorded at 24hours and 7days interval due to Neem plant products treatments. NKO at the rate of 1ml/35g of dried fish resulted in a high mortality of *D. maculatus* adult at 24, 48, 72 and 96 hours PTA, with the highest mortality recorded at 48hours PTA, and it was highly significant (P=0.01) statistically from the adult mortality recorded from NKP and NLP at the rate of 5g/35g dried fish each. However, these figures were not significant statically when compared with figures obtained from NKP and NLP at

24, 72, and 96 hours PTA. The cumulative adult mortality figures obtained after 96 hours showed that NKO resulted in a higher mortality of *D. maculatus* adult that was statistically significant than the adult mortality recorded from NKP and NLP (P=0.05). There was no significant difference statistically on the adult mortality of *D. maculatus* recorded from NKP and NLP. Following 7days PTA, NKO and NKP resulted in a significant (P=0.01) high mortality of the *D. maculatus* adult. But there was no significant difference in the mortality of D. maculatus adult recorded on fishes treated with NKO and NLP. However, NLP at 14, 21 and 28 days PTA also resulted in the mortality of *D. maculatus* adult, but this was not different statistically from NKO and NKP during the same periods. The cummulative mortality of *D. maculatus* adult obtained after 28 days PTA showed that NKO and NKP resulted in higher mortalities of *D. maculatus* adult than NLP but these figures do not differ statistically. The resultant high mortality of *D. maculatus* adult observed on dried fishes treated with NKO could be due to high toxicity of the product on the insects. This shows its potential in inducing mortality of *D. maculatus* adult. This observation is supported by Cobbinah and Appiah-K wartenq (1989) using NKO to control maize weevil (Sitophilus zeamyis) on maize grains. Senguttuvan *et al* (1995) also reported the effectiveness of NKO for the control of rice moth (Corcyra cephalonica). The NKP and NLP also resulted in the mortality of *D. maculatus* adult on the treated fishes, but these were not as effective as NKO. The observed low mortality of the insects could be due to low toxicity of the two Neem products. Cobbinah and Appiah-kwarteng (1989) also observed low toxicity from NLP on maize weevil which he attributed to the settling down of the powder particles at the bottom of the test bags. Similar observation was made during the study on NKP and NLP. But other studies have shown that NKP and NLP were effective against various insect such as the lesser grain borer on maize and wheat (Rhyzopertha dominica) when exposed for prolong period (Jotwani & Sircar, 1965, Sharma, 1995). The ineffectiveness of these two products in this study could be due to differences in the test insect, geographical location as well as environmental conditions at which the study was carried out.

TABLE III: EFFECT OF NEEM PLANT PRODUCTS ON THE RATE OF OVIPOSITION OF *Dermestes maculatus* Deg. ON DRIED FISH

		Mean number of egg per period of observation				
TREATMENTS		Days Post Treatment Application (HPTA)				
Neem Plant Products	Rate/35g Dried Fish	7	14	21	28	Cumulative Mean
Neem Kernel Oil (NKO)	1ml	0.71b	0.71	0.71	0.71	2.84b
Neem Kernel Powder (NKP)	5g	0.71b	0.71	0.71	0.741	2.84b
Neem Leaf Powder (NLP)	5g	1.87a	1.80	0.71	0.71	5.09ab
Control		1.00ab	2.12	1.10	1.87	6.09a
SED±		0.47	0.81	0.27	0.82	1.27
LSD		1.08	1.87	0.62	1.89	2.93
SIGNIFICANCE	NS	*	NS	NS	NS	*

Table III shows the effect of the Neem plant products on the rate of oviposition of *D. maculatus* on the treated dried fishes. Significantly, fewer numbers of eggs were deposited on fishes treated with NKO and NKP at 7 days PTA, but NLP resulted in high significant rate of oviposition than NKO and NKP (P=0.05). But there was no significant difference statistically between NKO and NKP in the rate of oviposition by the insect. During 14, 21 and 28 days PTA, the rate of oviposition recorded from the NLP and the control were higher, but these were not significant statistically (P=0.05). Although, analysis of variance shows no significant difference in the cumulative oviposition rate following 28 days PTA between the treatments, but the control resulted in a higher rate of oviposition that was significantly different (P=0.05) from NKO and NKP, but statistically similar to NLP.

The fewer number of eggs laid on dried fishes treated with NKO and NKP could be as a result of high mortality of the insects, thus disrupting mating and sexual communication as well as deterring females from laying eggs and causing adult sterility (Warthen, 1989 and NRC, 1992). However, the higher numbers of eggs laid on dried fishes treated with NLP could be due to the low mortality of the insects and the inability of the products to prevent and /or disrupt egg-laying by the adult females of the insect. Because dry ground Neem seed have been found to reduce fecundity, prolong pre-imaginal developmental period and considerably reduces emergence of progeny (Ivbijaro, 1983). The extracts from the Neem are also known to act on different insect species in various ways including repelling adults and larvae, disrupting developmental processes, inducing adult sterility and disturbing adult behaviour (Warthen, 1989).

TABLE IV: EFFECT OF NEEM PLANT PRODUCTS ON THE RATE OF EMERGENCE OF F_1 GENERATION OF ADULT *Dermestes maculatus* Deg. ON DRIED FISH

		Mean number of emerged F_1 per period of observation			
TREATMENTS		Weeks Post Treatment Application (WPTA)			
Neem Plant Products	Rate/35g Dried Fish	4	8	12	Cumulative Mean
Neem Kernel Oil (NKO)	1ml	0.71	0.71b	0.71b	2.13b
Neem Kernel Powder (NKP)	5g	0.71	0.71b	0.71b	2.13b
Neem Leaf Powder (NLP)	5g	0.71	0.71b	0.71b	2.13b
Control		0.71	2.40a	2.37a	5.48a
SED±		0.00	0.59	0.69	1.24
LSD		0.00	1.36	1.59	2.86
SIGNIFICANCE	NS	NS	*	*	*

Table IV shows the effect of Neem plant products on the emergence of F_1 generation of *D. maculatus* adult at 4weeks interval. Following the treatments of the dried fish with the Neem plant products, there were no emergence of F_1 generation of *D. maculatus* from the test insect in all the three treatments. At 8 weeks and 12 weeks PTA, there was also no emergence of *D. maculatus* from the three Neem products treatments at the rates evaluated. No significant difference exists statistically between the various Neem plant products treatment after 12weeks PTA. Hence, all the treatments suppressed the emergence of the F_1 generation of *D. maculatus* over the control. This observed non-emergence of F_1 generation of *D. maculatus* on the dried fishes treated with the three Neem products was as a result of complete suppression of the developmental stages of the insect. Although higher number of eggs were laid on dried fishes treated with NLP, but the product prevents further development of the insect from egg-stage to adult –emergence. This observation has been corroborated by several workers on various insect using various Neem products which were effective in reducing the emergence of next generation and their number (Sharma, 1995 and Senguttuvan *et al*, 1995). Neem products such as NKO have also been found to cause a reduction in fecundity and emergence of progeny of *Callosobruchus maculatus* as well as having larvicidal and other deleterious attributes (Ivbijaro, 1983). Similarly, Neem leaf or seed powder have been found to effectively reduce the progeny production of Sitophilus oryza and S. zeamais by disrupting the larval development and adult fecundity (Pereira and Wohlygemut, 1982). Ground Neem seed also reduces fecundity, prolongs pre-imaginal developmental period and considerably reduces emergence of progeny (Ivbijaro, 1983). The palatability test carried out showed that out of the three Neem products only NKO was found known to have any unpleasant or bitter taste on the dried fishes. These fish gave good taste and aroma as the untreated dried fishes. NKP and NLP were found to induce mild bitter taste on the treated dried fishes and the bitterness was more pronounced on those fish treated with NLP. However, the three Neem products were found not to impart any unpleasant odour in the treated dried fishes after cooking and consumption by the selected respondents.

Conclusion and Recommendation

The potentials efficacy of Neem kernel oil (NKO), Neem kernel powder (NKP) and Neem leaf powder (NLP) at the rate of 1ml, 5g and 5g/35g of dried fish respectively were evaluated for the control of dermestid beetles (*D. maculatus)* on the treated dried fishes. NKO was found to cause higher mortality of *D. maculatus* adult, but NKP and NLP were not as effective as NKO in terms of their toxicity to the adult of the insect. Both NKO and NKP were found to result in lower rate of oviposition and adult emergence after 12weeks PTA. The palatability test carried out on the treated dried fishes with the three Neem products showed only NKO not to have negative effect on the taste of the dried fishes where as NKP and NLP were found to impart mild bitter taste on the treated dried fishes.

Therefore, from the results obtained from this study, the use of Neem Kernel oil (NKO) at the rate evaluated is therefore recommended because of its potential to serve as a protectant of dried fish against dermestid beetle (*D. maculatus*) than NKP and NLP, and because of its non-bitterness which could endear it to consumers. NKO can easily be obtained from the widely available Neem trees with no specialized technology and can readily be used as local insecticide for the control of this insect as alternative to synthetic insecticides which are very expensive and could constitute potential health hazard to man and his environment. This simple technology can readily be adopted by dried fish traders to control the destructive dermestids beetles during processing, storage, transportation and marketing stages of dried fish trade.

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