Prevention of Infestation by *Dermestes maculatus* Degeer in East African Dried Fish using Pyrethrum and Piperonyl Butoxide

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East African sun-dried fish dipped for 4 seconds in different solutions of pyrethrum and piperonyl butoxide were analysed for insecticide residue limits. All analyses showed residues above the FAO/WHO MRL; exceeding factors of between 7.6 (22.9 ppm) and 1.6 (5.3 ppm) were found for pyrethrum while exceeding factors between 5.1 (102 ppm) and 1.7 (33.1 ppm) were common for piperonyl butoxide after 6 months' storage at ambient temperature. All insecticide treated fish, regardless of dip concentration, were observed to be less susceptible to infestation by *Dermestes maculatus* than samples of untreated fish. No dry weight losses due to insect infestation were recorded, however moisture evaporation caused weight losses between 6 and 8% duing the period. Further investigations showed that careful handling and a dip concentration more in accordance with FAO/WHO MRL than the commercial practice will reduce the cost of insecticides from K.sh. 0.72 to K.sh. 0.23 per kg pyrethrum treated fish.

Use of protectant insecticides for direct application to dried fish is well documented (McLellan, 1964; Green, 1967; Proctor, 1972; Diouf, 1980; Taylor & Evans, 1982; Golob *et al.*, 1984; Kalaimani *et al.*, 1987). Pyrethrum syngergized with piperonyl butoxide (POB) have until recently been the only insecticides which have maximum residue limits (MRL) recommended by the FAO/WHO Joint Committee on Pesticide Residues and most of the published work has therefore been confined to the application of these insecticides in the dried fish industry. The present MRL are 3 ppm pyrethrins and 20 ppm POB.

Severe difficulties, however, occur as pyrethrum has become expensive and not always accessible. Moreover, the active ingredients are reported to be rapidly degraded by sunlight (Casida, 1973). This situation has accelerated research on obtaining alternative insecticides and the recent approval by the FAO/WHO Working Meeting on Pesticide Residues on a MRL of 10 ppm pirimiphos methyl is directly related to the research on alternative insecticides carried out by TDRI (Taylor & Evans, 1982; Golob *et al.*, 1984; Walker & Golob, 1985).

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However, in parts of Africa and especially in the major pyrethrum producing countries like Kenya and Tanzania, pyrethrum is continuously available and relatively inexpensive.

The use of pyrethrum as an overall protectant against pest infestation is widespread and the future demand is expected to be high (Anon, 1984). The aim of this work, conducted at Lake Turkana, Kenya was to obtain a dried fish product similar in accordance with the FAO/WHO regulations, as residue limits of commercially treated local dried fish in some cases was reported to be 11 times higher than the MRL (Golob *et al.*, 1984). The role of the major pest *D. maculatus* during storage of fish, economic consideration and their application to local fish handling routines are also highlighted.

Materials and Methods

The work was carried out in Kalokol, the main centre of fish processing at Lake Turkana, between May and November, 1985. A large 200 m² concrete building served as the main fish store. During the time of experiments the store contained approximately 30 tonnes of dried fish which were partly infested by an indigenous stock of *D. maculatus*. The local fish, chubule *(Labeo* *horie),* was chosen as reference for two reasons; at present Labeo is the commercially most valuable fish species, besides it is also known for its high fat content (between 6 to 8%) and fatty fish are considered more susceptible to insect infestation than lean fish (Anon, 1981). The fish for the experiments were as uniform as possible, ranging the total length between 45 and 48 cm, with average weight of 450 to 500 g. Each fish was split and dried at ambient temperatures for 6 days before trial. The moisture content of a random sample of 25 fish was 11.5%.

The following procedure was then followed in the experiments:

10 fish of approximately 5 kg were arranged in three separate replicate bundles represented by Batch A to G, totalling 21 bundles, plus three extra for insecticide analysis (Batch A to C). Each fish was dipped individually for 4 seconds in 10 litres of insecticide solutions of different concentrations. Fish were then drained for 30 seconds and left for 3 h on wooden pallets to drain further. All replicate bundles were weighed every day for one week until the weight remained constant. Fish were re-examined intially (1 week), after 2 months, 4 months and 6 months. On each occasion, insect numbers, weight, temperature, relative humidity (all batches) and samples for insecticide analysis (only Batch A to C) were recorded. During final weighing, each fish was broken up and examined carefully for the presence of insects.

Insecticide concentrations of different batches were as follows:

A 0.009% pyrethrum
  0.018% piperonyl butoxide
B 0.018% pyrethrum
  0.036% piperonyl butoxide
C 0.036% pyrethrum
  0.072% piperonyl butoxide
D Blank
E 0.018% pyrethrum
F 0.036% piperonyl butoxide
G 0.018% pyrethrum
  0.144% piperonyl butoxide

High Pressure Liquid Chromatography (HPLC) method was used for determining pyrethrum and POB residues (Zweig & Sherma, 1977).

Total number of *D. maculatus* larvae/pupae and adults was counted and weight losses were recorded. The commercial fish handling procedure involves dipping of individual fish. Wastage of fish dip due to lack of drainage as well as unequal length of dipping were noted. An unsophisticated system was introduced with a drainage table and baskets leading excess fluid back to the main tank (Gjerstad, 1986).

Results and Discussion

Seasonal changes in ambient temperature, relative humidity and light intensity were recorded. Temperature changed between 29°C at 7 am and 36°C at 5 pm, relative humidity between 56% at 7 am and 42% at 5 pm and light intensity between 36 and 42 lux were normally found.

The closest residue limits to MRL were found in Batch A which for pyrethrum show residue limits of 7.9, 6.1, 5.4 and 5.3 ppm after 1 week, 2 months, 4 months and 6 months respectively, and for POB levels of 33.1, 32.9, 62.2 and 33.1 ppm during identical storage period. Batch B gave considerably higher results for pyrethrum; 29.2, 21.1 and 23.9 ppm after 1 week, 2 months and 4 months. For POB the same trend was evident with 79 ppm after 1 week, 72.7 ppm after 2 months and 126.7 ppm after 4 months. The 6 months samples from Batch B were unfortunately missing. Batch C showed alarmingly high residue limits for both pyrethrum and piperonyl butoxide. For pyrethrum the residues were 72, 62.8, 39.1 and 22.9 ppm after 1 week, 2 months, 4 months and 6 months. For POB the results showed 168, 151.7, 152.5 and 102 ppm after the same period of time. The results are presented in Fig. 1.

It is further apparent that for untreated fish in Batch D and for fish treated only with POB in Batch F, there was a distinct infestation in terms of both adults and larvae/pupae after 1 week while the other batches were only marginally infested. After 2 months, adults were present in all batches although Batch A, D and F were slightly

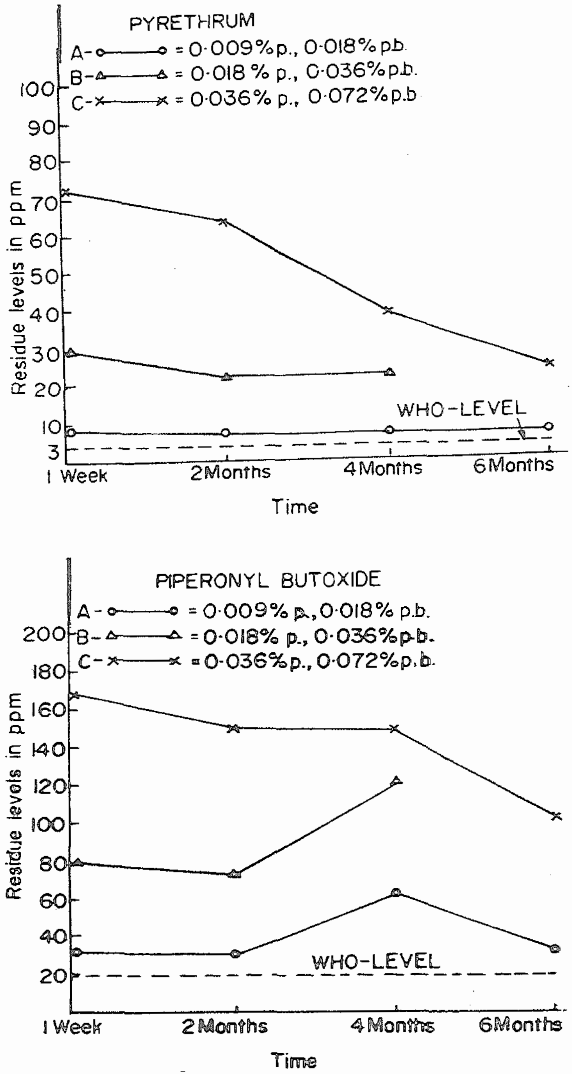

Fig. 1. Insecticide residues during storage

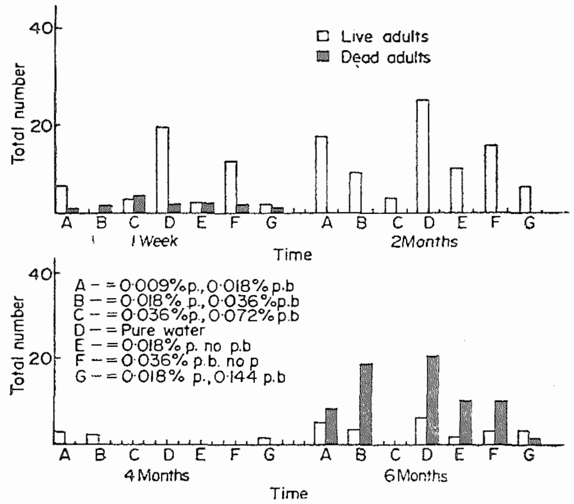

Fig. 2. Number of *Dermestes maculatus* adults during storage

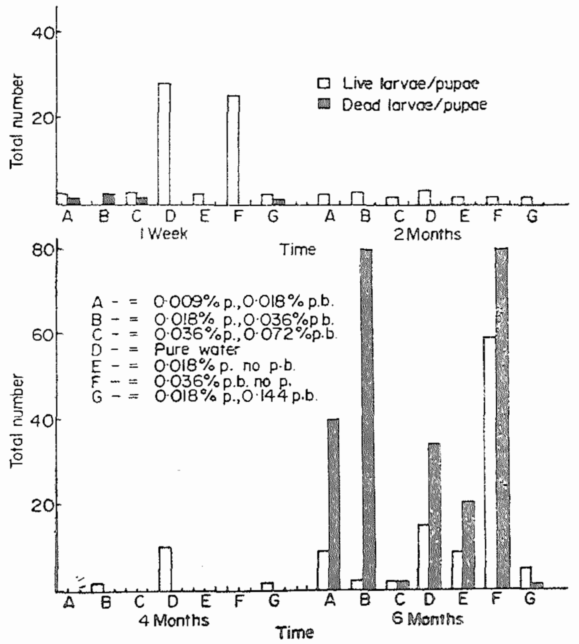

Fig. 3. Number of *Dermestes maculatus* larvae/pupae during storage

more infested than the others. For larvae/pupae the results are different with a widespread but only marginal infestation after 2 months. After 4 months few signs of either larvae/pupae or adults were recorded. The pest had however increased after 6 months which was especially evident for larvae/pupae where Batch F and to a lesser extent also Batch A, D and E were infested. Total number of dead insects was high in most batches but especially for larvae/pupae. The results are presented in Figs. 2 and 3.

The weight losses due to moisture evaporation were considerable with an average loss of 6.3 % of initial weight after 2 months, 8.5 % loss after 4 months and 8.0 % loss after 6 months, i.e. a slight increase in weight from the 4th to the 6th month. The results are presented in Fig. 4.

The residue analysis showed that all treatments resulted in exceeding the MRL. However, Batch A represented by 5.3 ppm pyrethrins and 33.1 ppm POB after 6 months storage is relatively close to the MRL of 3 ppm pyrethrins and 20 ppm POB. Taken into consideration that most dried fish from the Turkana district often stays for 10 to 12 months in warehouses before consumption it is expected that the actual

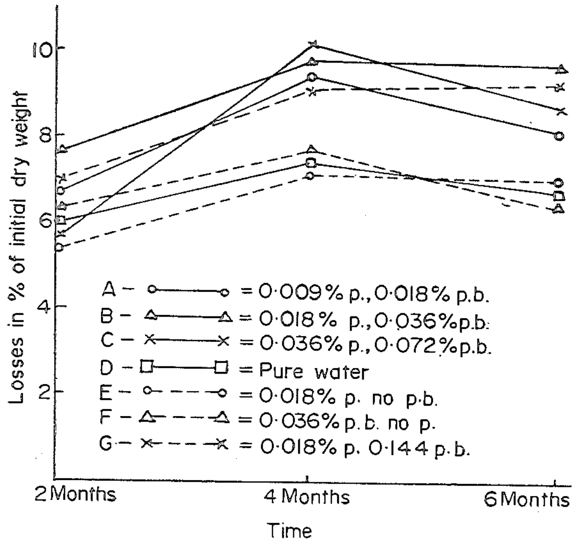

Fig. 4. Weight losses during storage

residues will be close to or even below the MRL by the time the product reaches the consumer. Moreover, Batch A gave better protection when compared with Batch D (untreated fish) or Batch F(only POB treated fish), However, the protection was not as effective as the one obtained in Batch B and C or in the commercial concentration represented by Batch G.

The rapid breakdown of pyrethrins (Casida 1973; Taylor & Evans, 1982), was only partly noted during this experiment. For the highest dosage of pyrethrum in Batch C (0.036 %) a much more pronounced reduction in residues occurs during storage. The final residue exceeded the MRL by a factor of 7.6. A reduction in residue limits for POB was only observed for Batch C (0.072 %). The residue for the two others are constant or increasing after 2,4 and 6 months. The slow or even lack of degradation found for pyrethrum and especially POB during storage should be noted and may be partly explained as due to the relatively dim storage facilities at Lake Turkana of 30 to 40 lux.

The insect counts show an unexpected picture; an initial stock after 1 week, a reduction of especially the larvae/pupae population after 2 months, an almost complete absence of insects after 4 months followed by a major infestation for some batches after 6 months. One explanation may be found in the indigenous stock of spiders of the family *pholcidae* in the fish store. It was observed that these spiders acted as predators on *D. maculatus,* in some bundles as many as 90% of the beetle pupae were infested leaving a hole, the size of a needle-head, on the pupae top. Inside, the shell was empty and the infested pupae could easily be selected from those successfully hatching. A reduction of fish quality by the presence of spiders was not noted. Human countermeasures or climatic changes which could explain the development of the pest stock were not noted in or close to the fish during experiments.

The initial moisture content was used to calculate the dry weight of the fish as insect losses were thought to be expressed on dry weight basis. Previously, considerable dry weight losses were found in Senegal (Diouf, 1980) and losses of as much as 18% for African tilapia have been reported (Golob *et al.,* 1984). However, during this trial, the dry weight losses were small and therefore regarded as of minor interest. The amount of 'fish dust' (fractions of eaten fish and faeces from insects) was only 45 g for the whole trial during 6 months.

It is suggested that improvements in handling routines by the introduction of a new fish dip unit (Gjerstad, 1986), a proposed reduction from Batch G (0.018% pyr., 0.144% POB) to Batch A (0.009% pyr., 0.018% POB) and thereby a reduction in the ratio of pyrethrum to POB from 1/8 to 1/2, will lead to an overall reduction in the cost of insecticides (Table 1).

Table 1. *Concentration of insecticides and and cost estimate*

	Commercial	Proposed
Pyrethrum %	0.018	0.009
Piperonyl butoxide %	0.144	0.018
Ethylan c. p%	0.144	0.018
Volume (litres) dip for 1500 kg of fish	400	260
Cost (K. sh.) per 100 litre dip solution	72	23
Cost (K. sh.) of dip per kg fish	0.19	0.04

Pyrethrum purchased as oleo resin containing 25% active ingredient @ K. sh. 500/kg (Pyrethrum Board, Kenya), piperonyl butoxide @ K. sh. 50/Kg and Ethylan c. p. @ K. sh. 50/kg emulsifier (10 K. sh. = 0.5 US $)

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