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Efficiency of organic pesticides, turmeric (*Curcuma longa*) and neem (*Azadirachta indica*) against dry fish beetle (*Dermestes* sp.) during storage condition

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Abstract

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Efficacy of turmeric (*Curcuma longa*) and neem (*Azadirachta indica*) or repelling dry fish insects (*Dermestes* sp. adult and larva) was investigated on the basis of their repellency rate, storage quality, sensory attributes of turmeric and neem treated dry fish and their cooked products. Pesticides prepared from turmeric and neem, were used in the form of extract and powder. The extracts were tested at the concentrations of 2%, 3%, 5% for turmeric and 3%, 5%, 7% for neem. Turmeric and neem powder were used for treatment at the rate of 2.0%, 3%, 4.0% upon 100 g dry fish. Repellency rate of *Dermestes* sp. adults was highest, where larvae showed mere resistance against herbal pesticides. Pesticides prepared from turmeric were more repellent than neem pesticides. Control and treated dry fish had almost similar sensory attributes after the 2nd month. However, odor, texture, general appearance and insect occurrence of control dry fish decreased significantly after 4th month of storage but all those parameter of treated dry fish were nearly unchanged. However, sensory quality of dry fish treated with turmeric and neem were remain unchanged after the 4th month. The results suggested that 3% extract and powder of turmeric or neem at the rate of 5% extract and 3% powder can be used as suitable field doses for direct application in dry fish to prevent insect infestation during storage of dry fish products.

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Introduction

Dry fish is one of the popular and preferred food items in Bangladesh. It is the staple source of protein in many areas of our country like Chittagong, Dhaka, Chandpur, Kuakata, Barisal etc. In Bangladesh, drying of fish performed under direct sunlight and open air and around one-fifth portion of total fish caught are sun-dried and commonly eaten by the local people annually (Newsad, 2005). Dried fish is one of an important exportable item which earns a substantial amount of foreign currency (Sen *et al.*, 2016).

Major problems related to the sun-dried fish products are the infestation by blowfly during drying process and beetle larvae during storage. Up to 50% losses by weight due to *Dermestes* sp. attack have been recorded by many observations when unsalted dried fish is stored for 6 month (Green, 1967). *Dermestes* sp. beetle appears to be the major insect although other minor beetles like *Nacrobia* spp. can also damage the dried products (Newsad, 2005).

Application of hazardous pesticides like DDT, nogos are generally practiced as preventive and curative measures against insect infestation in Bangladesh (Newsad, 2005),

beyond those, harmful chemicals like dichlorovos, naphthalene, paradichlorobenezene, malathion and chloropyrifos are repeatedly applied on fish during sun drying (Bennett *et al.*, 1988; Jubb and Perkins, 1985). Because of the detrimental effect on human health greater portion of the pesticides are banned in Bangladesh for any type of use (Barua, 2007). Application of such hazardous pesticides relatively at higher dose in dry fish, often responsible for major health crisis to the human body (Khan *et al.*, 2002)

Considering the harmful effects of chemical pesticides on human health, a total restriction on their usage in dry fish and finding out suitable alternatives are of great necessity. Some spices like turmeric, red chili, neem, garlic etc. have pesticidal effects and could be applied as alternative preservatives in oppose to infestation of insects in dry fish. Some recent laboratory research revealed that medicinal plants like neem (*Azadirachta indica*) and turmeric (*Curcuma longa*) have strong repellent effects on beetles and mites of dry fish. However, efficacy of such herb to repel dry fish insects and pests, sensory quality of dry fish and their consumer acceptance after treatment have not been known yet. Hence, objective of the present study was to determine

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effectiveness of turmeric and neem extract and powder in repelling insect and pests of dry fish. Determination of field dosage of these herbs against *Dermestes sp.* was carried out, moreover sensory quality of dry fish treated with turmeric and neem and cooked products of those treated dry fish was also evaluated.

Materials and Methods

The experiment was conducted in the Laboratories of the Department of Fisheries Technology, Bangladesh Agricultural University, Mymensingh. The efficacy of both extracts and powder of turmeric and neem on repelling insects in dried fish were investigated.

Collection and processing of plant materials

Neem leaves were collected from roadside trees of Bangladesh Agricultural University campus and dried turmeric was purchased from local market of Mymensingh. Bringing the plant materials in to laboratory neem leaves were washed in running water and keep them for air drying, after that they were dried under the sun in open air for two consecutive days to gain constant weight.

Preparation of plant extract and powder

Neem water extract (stock solution) was prepared by taking 1 kg of green neem leaves in 2 liters of water, where as turmeric water extract (stock solution) was prepared by using 200 g of each dust dissolved in 2 liters of potable water, boiled for 60 minutes at 90°C, then filtered and cooled, finally make the volume of 500 ml in a measuring dark glass bottle and kept in the refrigerator for bioassay test (Lithi *et al.*, 2012). Dried portions of turmeric and neem powder were prepared with the help of a grinder (Preethi ECOCHEF MG159/BL) by pulverizing, uniform dust were obtained by using a 25-mesh diameter sieve. After that, the dust of neem leaves and turmeric were preserved in an airtight plastic container until further use in a direct application or extract preparation (Nowsad *et al.*, 2013).

Preparation of dried fish

Fresh jatpunti (*Puntius sophore*), were collected from local market and scaled, gutted and washed with clean water. Then turmeric extract at the rate of 2%, 3% and, 5% and neem extract at the rate of 3%, 5% and 7% were sprinkled over the fish by using a hand sprayer. Treated wet fish and untreated control wet fish were spread separately over the drying rack and dried for 3–4 consecutive days in order to reduce the moisture level less than 16%. After completion of the drying process, treated and control dried fishes were preserved separately in polythene bag to prevent absorption of moisture and kept in room temperature.

Collection and rearing of insect

Dermestes sp. (adult) and (larvae) were collected from dried fish markets of Mymensingh town. The insects were reared in plastic jars containing dry fish and kept in

a laboratory of the Department of Fisheries Technology at 27–30°C.

Insect bioassays and Repellency test

To determine repellency rate of turmeric and neem against *Dermestes sp.* (adult) and (larvae), insect bioassay was conducted in the Fisheries Technology Laboratory at 27 to 30°C temperature. Repellency test was conducted for adults *Dermestes sp.*, and larvae of *Dermestes sp.* according to the method of (Talukder and Howse, 1995).

Application of neem and turmeric on dry fish for repellency test

Turmeric and neem extracts treated dry fish with at different concentrations were used to determine the repellency rate of insects. Petridishes containing crushed dry fishes were divided into two parts with a free line space open along the middle of petridish. One part was treated with prescribed dose of neem or turmeric extract and untreated control sample was assayed in parallel in the same petridish (Plate 1). For turmeric and neem powder, untreated control dry fish were crushed and placed in a petridish by maintaining into two parts again. One part of dry fish was treated with three variables of turmeric and neem powders, *viz.*, 2.0%, 3.0% and, 4.0% by spreading over the dry fish part. Turmeric and neem powder treated dry fish was separated by a free line space along the middle of the petridish from the control untreated part. In the center, free-space line of each petridish ten insect was released and covered them. The number of insects present on treated and untreated portion was counted up to five hours at hourly intervals. The repellency class of turmeric and neem stock solution at different concentration levels varied between I to V.

The data were expressed as percentage repulsion (PR %) by the following formula:

$$PR (\%) = (NC - 50) \times 2$$

Where,

NC = Percentage of insects present in the control half.

Positive (+) values showed repellency and negative (–) values showed attractancy. Data (PR %) was analyzed using the analysis of variance (ANOVA). The average values were categorized as following class according to (Mc Donald *et al.*, 1970).

Use of extract and powder of turmeric and neem into dry fish for storage

Extracts and powders of turmeric and neem were applied at several doses to determine the efficiency of turmeric and neem pesticides on repelling insects, during the storage period of dry fish. As stated, the turmeric extracts were applied to the dry fish at the rate of 2%, 3%, 5 % and neem extract were applied to the dry fish at the rate of 3%, 5%, and 7%. Turmeric and neem powder was applied to the dry fish at the rate of 2.0%, 3.0%, and 4.0% in each 100 g dry fish pack. Pesticide-treated dry

fish and control dry fish were kept in polyethylene bags with open mouth condition to allow the movement of insects and stored at room temperature ($30.3 \pm 2.4^\circ\text{C}$).

Storage quality study of dry fish treated with turmeric and neem

Storage quality of turmeric and neem treated dry fish were investigated by sensory evaluation, the occurrence of insects, TVB-N values (Total Volatile Base Nitrogen) and microbial load determination.

Sensory evaluation of herbal pesticide-treated cooked dry-fish by the panel test

A trained panel of eleven-person of students, teachers and staffs of the Department of Fisheries Technology provided the sensory assessment of herbal pesticide-treated cooked dry-fish (Nowsad *et al.*, 2002). Before testing, panelist was familiarized with the properties of herbal pesticide-added cooked dry-fish and the instruction relating to the scoring of the sample. To determine the sensory quality of control and pesticide treated cooked dry fish, panelists scored cooked dry fish for color, flavor or odor and taste. The score of panel members were divided in to five categories such as 1 'excellent', 2 'good', 3 'average', 4 'bad', 5 'very bad'. Nine types of cooked dry-fish samples including control and herbal pesticide treated cooked dry-fish were supplied to each panelist to recognize every attribute.

Statistical analysis

The experimental data were statistically analyzed by completely randomized design (factorial CRD) using MSTAT statistical software in a computer. The mean values were compared by Duncan's Multiple Range Test (DMRT) (Duncan, 1951).

Results and Discussion

Repellent effect of turmeric and neem extracts and powder on (*Dermestes* sp.) adult and larvae

Repellency test was done on the adult and larvae of *Dermestes* sp. using turmeric and neem pesticides. The repellency rates of adult beetle against pesticides were presented in Table 1 and repellency rates of *Dermestes* larvae against pesticides were presented in Table 2. Turmeric and neem extract were applied at the rate of 2%, 3% and 5% and; 3%, 5% and 7%, respectively against *Dermestes* sp. adult to determine the repellency rate (Table 1). Application of 5% turmeric extract resulted highest mean repellency (61.66 %), on the other hand mean repellency was lowest (33.33%) with 3% neem extract. Increased concentrations of turmeric and neem extract increased the repellency rate (Jilani *et al.*, 1988). Repellency rate of turmeric and neem powder at 2%, 3%, and 4% were evaluated against *Dermestes* sp. adult. 4.0% turmeric powder got highest mean repellency (61.00%) where mean repellency was lowest (34.33 %) with 2.0% neem powder. Above findings showed that, extract and powder of turmeric at highest concentration was more repellent than extract and powder of neem.

To determine the repellency rate of turmeric and neem extract were used 2%, 3% and 5% for turmeric and 3%, 5% and 7% for neem extracts against larvae of *Dermestes* sp. beetle (Table 2). The Rate of repellency and mortality of beetle larvae rose with higher concentration of doses (Xia *et al.*, 2010). Highest mean repellency (57.00 %) was found with 4% turmeric extract and the lowest mean repellency (29.67 %) was found with 3% neem extract. Furthermore, the repellency rate of turmeric and neem powder was used at 2.0%, 3.0%, 4.0%. Highest mean repellency (52.67 %) was found with 4.0% turmeric powder and 2.0% neem powder showed lowest mean repellency (22.66 %). From the above results, it was apparently observed that turmeric extract and powder at highest concentration showed more repellent effect than neem extract and powder. The chemical compound of turmeric has the repellency effect by blocking the intake of oxygen or by other negative factor (Jilani *et al.*, 1990).

Changes in the sensory quality of stored dry fish treated with turmeric and neem

Dry fish which treated with extract and powder of turmeric and neem were packaged in polyethylene bags and stored at temperature ($30.3 \pm 2.4^\circ\text{C}$) with open bag mouth to allow occurrence of insects. Data for color, flavor, texture, general appearance and insect's occurrence of control and treated dry fish at 2nd and 4th month of storage period at room temperature are presented in (Table 3). Sensory attributes, general appearance of both control and treated dry fish were nearly similar up to 2nd months of storage at same temperature. After 2nd months, color and odor changes were observed due to use of turmeric and neem, but other parameter like general appearance and texture of dry fish were remained acceptable. As extract and powder of neem applied directly, color of dry fish had changed towards brown to dark. When higher doses of turmeric or neem were used, color change observed from yellowish to brownish and finally into dark. However, the natural dry fish odor persisted throughout the period after all doses applied. After 2nd months, dry fish treated with turmeric or neem occurrence of insect was not observed, except untreated control (attacked by beetle, 4 insects) and dry fish treated with 2.0% neem powder (attacked by beetle, 1 insect). After 4 months of storage, however in control dry fish, the sensory attributes like odor, texture and general appearance was deteriorated sharply and the occurrence of insects increased markedly. As opposed to, dry fish treated with turmeric/neem all the mentioned attributes were not fallen even after 4th months. Daramola *et al.* (2007) found that when smoke-dried Tilapia was stored at ambient condition (25°C), the physical attributes such as color, fragmentation, odor, taste, and texture of dry fish was declined at storage condition. Result obtained from repellency tests showed that extract and powder of turmeric were more repellents than neem extract and powder. So that, neem extract (3, 5 and 7%) was applied at higher concentration than extract of turmeric (2, 3 and

4%). Sensory attributes like color, was deteriorated as concentrations of applied dosages of both turmeric and neem was increased, neem was mainly liable for development of unacceptable brownish to dark color of dry fish. Though keeping quality of dry fish was elevated with higher doses of extract and powder of neem and turmeric, but sensory quality of the products ultimately reduced. After 4th months of storage, control dry fish which remain untreated, attacked severely by beetle of *Dermestes sp.*, however, turmeric and neem treated dry fish was not attacked by insects. Exception found with 2.0% neem powder treated dry fish which was attacked by beetle (2 insects).

Changes in Total volatile base nitrogen (TVB-N) value of controlled and treated dry fish

Total volatile base nitrogen (TVB-N) is a generally used chemical method for determination of quality of fish and dry fish products. Values of TVB-N obtained from dry fish kept at temperature (30.3±2.4°C) were presented in (Fig. 1). Mid doses of both turmeric (3% extract, 3% powder) and neem (5% extract, 3% powder) were considered to evaluate the change of TVB-N values. At ambient temperature, rapid increment of TVB-N values was observed both in treated and control dry fish (Roy *et al.*, 2016). As the storage period increased, decomposition rate increased, as a result TVB-N value also raised (Plahar *et al.*, 1991). It was observed that, dry fish treated with various doses of turmeric and neem products, was not significantly affect instant change of TVB-N values.

Changes in microbial load of the pesticides treated dry fish at storage condition

The microbiological population of both control and treated products were investigated up to 4 months of storage period. The treated dry fish were stored in the room (30.3±2.4°C) and results presented in the Table 4.

Aerobic plate count (APC) result of both control and treated dry fish were in acceptable level along the storage period. In control dry fish, APC values were increased from 6.77 to 6.97 log CFU/g after 4 months of storage period. Use of extract and powders of both turmeric and neem significantly reduced the APC values from initial month to 4th months. Microbial load obtained from control and treated dry fish, fall within acceptable limit of APC of dry fish. Likewise APC value, application of turmeric and neem in both form showed better reduction of microbial load. Lithi *et al.* (2012) found that APC values decreased with increased doses of extracts and powders. Considering the factors like color, taste, insect occurrence, and general appearance, though all values of microbiological test were in safe range but relatively lower doses of extract and powder can be suggested as field dose for application on dry fish.

Sensory quality evaluation of turmeric and neem treated cooked dry-fish to determine consumer acceptance

Scoring result (Table 5) of control and herbal pesticide-treated dry-fish showed that higher doses of turmeric (5% extract, 4% powder) and neem (7% extract, 4% powder) was negatively affect the sensory parameter by developing unacceptable dark color, extreme turmeric or neem flavor and, bittertaste of cooked dry fish. On the other hand, cooked dry fish treated with middle doses of turmeric (3% extract, 3% powder) and neem (5% extract, 3% powder) got excellent score on color, odor and taste, and bitterness originated from turmeric or neem was significantly absent. Turmeric treated dry fish found as a better cooked product that those dry fish treated with neem.

Table 1. Repellent effect of turmeric and neem extract and powder at different dose levels on *Dermestes sp.* (adult) using crushed dried fish at different HAT (hours after treatment) (interaction of plant, dose and time)

Name of the plants extracts	Doses (%)	Repellency rate					Mean repellency	Repellency class
		1 HAT	2 HAT	3 HAT	4 HAT	5 HAT		
Turmeric extract	2.0	21.66	30.00	38.33	45.00	51.66	37.33 ^c	II
	3.0	25.00	35.00	43.33	51.66	58.33	42.66 ^b	III
	5.0	45.00	53.33	63.33	70.00	76.66	61.66 ^a	IV
Neem extract	3.0	20.00	26.66	33.33	40.00	46.66	33.33 ^c	II
	5.0	21.66	30.00	41.66	46.66	56.66	39.33 ^b	II
	7.0	41.66	50.00	61.66	68.33	71.66	58.66 ^a	III
Turmeric powder	2.0	20.00	28.33	36.66	43.33	51.66	36.00 ^c	II
	3.0	33.33	41.66	48.33	55.00	60.00	47.66 ^b	III
	4.0	46.66	53.33	60.00	68.33	76.66	61.00 ^a	IV
Neem powder	2.0	20.00	28.33	33.33	41.66	48.33	34.33 ^c	II
	3.0	23.33	33.33	45.00	48.33	55.00	41.00 ^b	III
	4.0	33.33	48.33	56.66	63.33	73.33	55.00 ^a	III

HAT= Hours after treatment. Mean repellency values within the column followed by different letters are significantly different ($P<0.05$).

Table 2. Repellent effect of turmeric and neem extracts and powder at different dose level on *Dermestes* sp. (Larvae) using crushed dried fish at different HAT (hours after treatment) (interaction of plant, dose and time)

Name of the plants	Doses (%)	Repellency rate					Mean repellency	Repellency class
		1 HAT	2 HAT	3 HAT	4 HAT	5 HAT		
Turmeric Extract	2.0	23.33	31.66	38.33	43.33	50.00	37.33 ^c	II
	3.0	33.33	41.66	50.00	55.00	63.33	48.66 ^b	III
	5.0	38.33	48.33	58.33	65.00	75.00	57.00 ^a	III
Neem extract	3.0	16.66	20.00	28.33	36.66	46.66	29.66 ^c	II
	5.0	23.33	30.00	36.66	43.33	53.33	37.33 ^b	II
	7.0	26.66	38.33	48.33	56.66	68.33	47.66 ^a	III
Turmeric powder	2.0	21.66	28.33	35.00	43.33	50.00	35.66 ^c	II
	3.0	21.66	31.66	41.66	46.66	56.66	39.66 ^b	II
	4.0	36.66	43.33	50.00	61.66	71.66	52.66 ^a	III
Neem powder	2.0	10.00	13.33	20.00	30.00	40.00	22.66 ^c	II
	3.0	18.33	23.33	30.00	40.00	50.00	32.33 ^b	II
	4.0	21.66	33.33	43.33	51.66	65.00	43.00 ^a	III

HAT= Hours after treatment. Mean repellency values within the column followed by different letters are significantly different ($P<0.05$).

Table 3. Sensory quality of treated dry fish in storage condition

Treated dry fish	Dose	2 nd Month of Storage					4 th Month of Storage				
		Colour	Odour	Texture	Appearance	Insect (No./Pkt)	Colour	Odour	Texture	Appearance	Insect (No./Pkt)
Control	-	1.7±0.3	1.4±0.5	1.2±0.2	1.7±0.3	4±0	7.7±0.2	4.7±0.3	4.3±0.4	5.3±0.2	9±1
Turmeric extract	2.0%	2.1±0.6	2.7±0.3	1.8±0.2	2.1±0.1	0	4.3±0.2	2.5±0.5	2.8±0.2	2.7±0.1	0
	3.0%	3.5±0.1	2.3±0.5	1.9±0.1	2.2±0.1	0	3.1±0.5	1.9±0.2	2.5±0.3	2.7±0.1	0
	5.0%	3.3±0.1	2.5±0.3	2.1±0.3	2.6±0.3	0	4.1±0.4	2.7±0.3	2.4±0.1	2.3±0.3	0
Neem extract	3.0%	3.5±0.5	2.1±0.3	2.4±0.3	1.5±0.2	0	5.7±0.2	3.1±0.7	2.3±0.7	2.5±0.3	0
	5.0%	4.7±0.8	2.4±0.1	1.9±0.5	1.8±0.4	0	6.3±1.0	2.2±0.2	2.5±0.1	2.7±1.0	0
	7.0%	3.4±0.1	2.5±0.7	1.3±0.7	1.6±1.0	0	7.7±0.5	2.3±0.7	2.5±0.3	2.4±0.0	0
Turmeric powder	2.0%	3.1±1.0	2.3±0.1	2.1±0.3	2.0±0.3	0	3.2±0.0	3.7±0.1	2.3±0.0	2.7±0.1	0
	3.0%	3.3±0.1	2.3±0.5	1.5±0.5	2.1±0.0	0	3.6±0.5	2.5±0.0	2.2±0.2	2.1±0.2	0
	4.0%	3.5±0.5	2.1±1.0	2.2±0.1	2.3±0.1	0	3.2±0.1	2.6±0.5	2.5±0.6	2.0±0.1	0
Neem powder	2.0%	4.8±0.2	2.2±0.3	2.2±0.6	2.7±1.0	1±1	7.3±0.3	4.1±0.1	2.3±1.0	3.4±0.3	2±1
	3.0%	5.2±0.0	2.5±0.0	1.9±0.5	2.6±0.0	0	8.1±0.5	3.7±0.3	2.1±0.3	2.7±0.2	0
	4.0%	4.3±0.5	2.3±0.2	1.7±0.3	2.2±0.1	0	8.1±0.1	3.5±0.0	2.2±0.0	2.3±0.4	0

Table 4. Changes in microbial load (APC) of control and treated dry fish stored at room temperature (30.3±2.4°C)

Product name	Dose	1 st Month of Storage		4 th Month of Storage	
		CFU/g	Log CFU/g	CFU/g	Log CFU/g
Control	-	5.9 ×10 ⁶	6.77	9.4 ×10 ⁶	6.97
Turmeric extract	2.0%	4.5×10 ⁴	4.65	6.2×10 ⁵	5.79
	3.0%	3.9 ×10 ⁴	4.59	5.1 ×10 ⁵	5.70
	5.0%	3.2 ×10 ⁴	4.50	4.7 ×10 ⁵	5.67
Neem extract	3.0%	4.7 ×10 ⁵	5.67	6.7 ×10 ⁶	6.82
	5.0%	4.1×10 ⁴	4.61	4.5×10 ⁵	5.65
	7.0%	3.7×10 ⁴	4.56	4.1×10 ⁵	5.61
Turmeric powder	2.0%	4.9×10 ⁴	4.69	6.8 ×10 ⁵	5.83
	3.0%	3.9×10 ⁴	4.59	4.6×10 ⁵	5.66
	4.0%	3.7×10 ⁴	4.56	4.3×10 ⁵	5.63
Neem powder	2.0%	5.7×10 ⁵	5.75	7.2×10 ⁶	6.85
	3.0%	5.2×10 ⁴	4.71	5.8×10 ⁵	4.76
	4.0%	4.7 ×10 ⁴	4.67	5.3×10 ⁵	5.72

Table 5. Sensory panel test of herbal pesticide-treated cooked dry-fish for determination of consumer acceptance

Cooked dry-fish	Sensory Characteristics			
	Color	Flavor /Odor	Taste	Comment
Control	1.0±0.0 ^a	1.0±0.1 ^a	1.0±0.7 ^a	Excellent
Neem Powder (3%)	1.2±0.1 ^a	1.4±0.3 ^a	1.3±0.3 ^a	Excellent
Neem Powder (4%)	3.9±0.6 ^c	3.1±0.4 ^c	3.9±0.6 ^c	Average
Turmeric Powder (3%)	1.1±0.0 ^a	1.5±0.3 ^a	1.4±0.5 ^a	Excellent
Turmeric Powder (4%)	2.7±0.2 ^b	2.4±0.5 ^b	2.9±0.5 ^b	Average
Neem Extract (5%)	1.2±0.3 ^a	1.7±0.3 ^a	1.8±0.2 ^a	Excellent
Neem Extract (7%)	3.6±0.7 ^c	3.2±0.5 ^c	2.6±0.6 ^b	Average
Turmeric Extract (3%)	1.3±0.4 ^a	1.3±0.2 ^a	1.4±0.3 ^a	Excellent
Turmeric Extract (5%)	2.3±0.2 ^b	2.4±0.1 ^b	3.2±0.4 ^c	Average

Score: 1= excellent, 2= good, 3= average, 4= bad, 5= very bad;

Figures with different superscripts in different columns and rows differ significantly ($P < 0.05$).

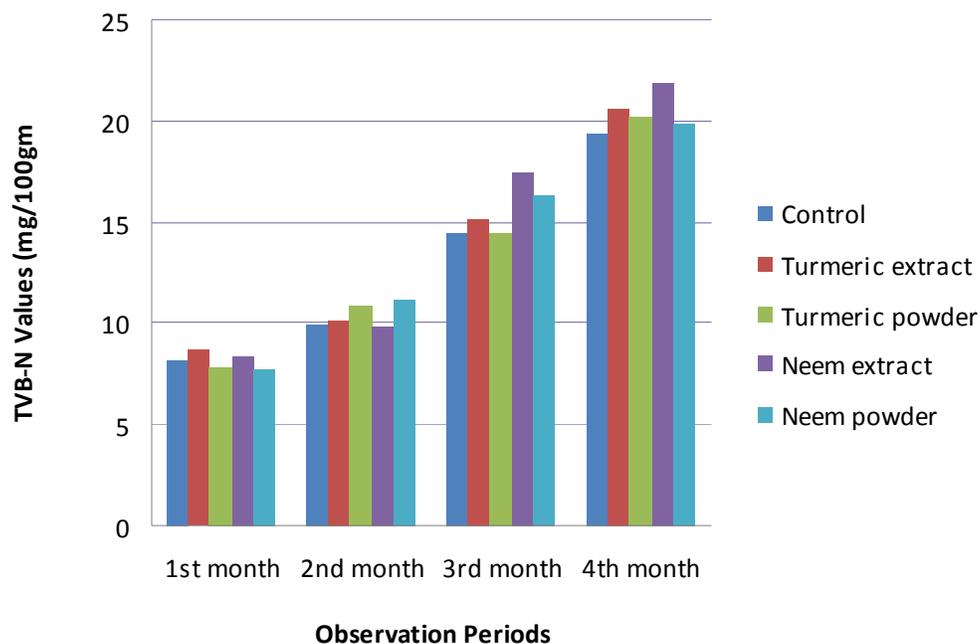


Fig. 1. Changes in TVB-N values (mg/100g) in control and treated dry fish stored at room temperature ($30.3 \pm 2.4^\circ\text{C}$)



Plate 1. Application of turmeric (a) and neem (b) on dry fish to determine the repellency test of *Dermestes* sp.

Conclusion

Turmeric and neem pesticides effectively repelled the infestation of *Dermestes* sp. insects in dry fish and pesticide-treated cooked dry fish obtained an excellent and acceptable score in terms of color, flavor and taste. These herbal pesticides could be a good alternative against harmful chemical pesticides and dry fish processors can be able to use crude turmeric and neem extracts or powders for controlling dermestid beetle in dry fish both during processing and storage. Turmeric extract and powder at the rate of 3% or neem at the rate of 5% extract or 3.0% powder could be suitable field doses for direct application in dry fish to repel insects while storing the products.

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