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Methods for decontamination of Sweet Flag Emulsifiable Concentrate (SFEC) formulation from maize and green gram seeds

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Abstract
Investigation were conducted to develop decontamination techniques for Sweet Flag, (*Acorus calamus* L.) EC formulation on rice weevil, *Sitophilus oryzae* (L.) and pulse beetle, *Callosobruchus maculatus* (F.) on maize and green gram seeds in storage during 2016-2017 at the Department of Agricultural Entomology, Agricultural College and Research Institute, Coimbatore. In the study to evaluate the decontamination techniques for sweet flag EC (SFEC) in terms of insecticidal action on *C. maculatus* in green gram seeds and *S. oryzae* in maize seeds, lowest mortality of *C. maculatus* (46.60%) and *S. oryzae* (1.10%) was observed in decontamination with lime solution 5 per cent while 100.00 and 72.2 per cent was observed in sweet flag EC without decontamination which indicated that lime solution might have removed the sweet flag EC formulation from the green gram and maize seeds.

Keywords: Decontamination techniques, green gram, maize, sweet flag

Introduction
Most of the stored products were lost during post-harvest than in field. Stored products were damaged by insect pests in which beetles, weevils and moth were common [11]. In India annual storage losses have been estimated as 14-15 million tons of food grains worth of Rs 7,000 crores every year in which insect accounts for nearly Rs 1,300 crores [15].

The control of foodstuff pests is also very difficult due to recent legislations that restrict the use of synthetic insecticides. Concerns about the residual toxicity of synthetic insecticides applied to stored grains and health hazards to grain handlers have prompted research for alternatives for protection of stored grains. Therefore, there is a worldwide need to find alternative molecules to traditional insecticides, in order to meet the growing demand for healthy and safe food [17]. Bioactive natural products or plant derived compounds were better alternative to synthetic insecticides for the management of stored product insects [12, 16]. Therefore, plant materials should be explored to protect the stored products against pest infestation.

Botanical insecticides are natural chemicals extracted from plants with insecticidal properties and used as an excellent alternative to synthetic or chemical pesticides for crop protection to avoid negative or side effects of synthetic insecticides. Plant based insecticides were eco-friendly and promising alternative to chemical pesticides for controlling stored product insects, which avoids the negative or side effects of synthetic insecticides. Botanical pesticides (essential oils, flavonoids, alkaloids, glycosides, esters and fatty acids) have dynamic nature (repellents, feeding deterrents/antifeedants, toxicants, growth retardants, chemosterilants, and attractants) that act on insects in different ways [5]. The potential candidates for crop development and commercialization for sources of insect attractants, repellants or toxicants are *Acorus calamus, Artemisia tridentata, Heliopsis longipes, Tagetes minuta, Azadirachta indica, Mammea americana and Ocimum basilicum* [6].

Among the plant products evaluated for their efficacy against stored products, *A. calamus* (sweet flag) was found to be the most promising for the management of stored product insects [2, 3, 4, 13]. The persistence toxicity of sweet flag formulation on green gram and maize seeds upto 90 days. The present study deals with basic or household process to remove the SFEC residues from green gram gram and maize.

Materials and Methods

Evaluation of decontamination techniques for Sweet Flag Emulsifiable Concentrate (SFEC) formulation interms of insecticidal action on *S. oryzae* and *C. maculatus*

Twenty gram seeds of green gram and maize were treated with one per cent Sweet Flag Emulsifiable Concentrate (SFEC) formulation and subject to different decontamination methods *viz.*, sun drying for 6 hours, washing with running tap water and hot water washing for 5minutes, soaking (2% NaCl solution, 2% tamarind solution, 2% sodium bicarbonate and 5.00% lime solution) for 15 minutes. Decontamination methods were done with sweet flag EC treated seeds on 3 days after treatment. Untreated control was also maintained. Three replications were maintained for each treatment.The seeds were shade dried and transferred into a plastic jar. Treated seeds were maintained as control and untreated seeds were maintained as standard check. Thirty (15 pairs) newly emerged adults of *S. oryzae* and *C. maculatus* were released into each plastic jar. Mortality was recorded at 24 hours intervals for seven days. The mortality of pulse beetle and rice weevil in different decontaminated seeds were correlated with the content of SFEC formulation retention in the decontaminated seeds.

Statistical analysis

The data were subject to statistical analysis. Square root and arcsine transformations were adopted for the data transformation of numbers and percentage, respectively [1]. Means in simple CRD analysis were separated by Least Significant Difference (LSD) test.

Results

Evaluation of decontamination techniques for Sweet Flag Emulsifiable Concentrate (SFEC) in terms of insecticidal action on *S. oryzae* in maize seeds.

SFEC treated seeds were decontaminated with different treatments and the mortality of *S. oryzae* observed in different treatments are furnished in Table 1. On 1st DAT, highest per cent mortality was recorded at SFEC treated seeds (43.30%) followed by 2.20, 2.20, 1.10, 1.10 and 1.10 per cent mortality decontaminated with 2.00 per cent sodium chloride, 2.00 per cent tamarind solution, hot water washing, sundrying and tap water washing, respectively while 2.00 per cent sodium bicarbonate, 5.00 per cent lime solution and untreated check showed no mortality. On 3rd DAT, 97.78 per cent mortality was recorded in SFEC treated seeds, followed by 11.10, 7.77, 6.67, 6.67 and 3.30 at 2.00 per cent tamarind solution, sundrying, tap water washing, hot water washing and 2.00 per cent sodium chloride, respectively while 2.00 per cent sodium bicarbonate, 5.00 per cent lime solution and untreated check showed no mortality. On 7th DAT, cent per cent mortality was recorded in SFEC treated seeds followed by 12.20,11.10, 10.00, 10.00, 10.00, 6.67 and 1.10 at 2.00 per cent tamarind solution, 2.00 per cent sodium chloride, sundrying, tap water washing, hot water washing, 2.00 per cent sodium bicarbonate and 5.00 per cent lime solution respectively. It can be concluded that 5.00 per cent lime solution was the best decontamination treatment.

Evaluation of decontamination techniques for Sweet Flag Emulsifiable Concentrate (SFEC) in terms of insecticidal action on *C. maculatus* in green gram seeds.

SFEC treated seeds were decontaminated with different treatments and the data recorded on mortality of *C. maculatus* in different treatments are furnished in Table 2. The mortality of pulse beetle in different decontamination treatments were correlated with the sweet flag extracts content retention in the decontaminated seeds. On 1st DAT, highest per cent (47.78%) mortality was recorded in SFEC treated seeds followed by 12.00, 8.00, 7.00, 2.00 and 2.00 per cent in tap water washing, sundrying, 2.00 per cent sodium bicarbonate, 2.00 per cent tamarind solution and 5.00 per cent lime solution, respectively while 2.00 per cent sodium chloride and untreated check showed no mortality. On 3rd DAT, 95.56 per cent mortality was recorded in SFEC treated seeds followed by 30.00, 24.00, 22.00, 21.00, 21.00, 18.00, 12.00 and 11.00 per cent in tap water washing, hot water washing, 2.00 per cent sodium bicarbonate, sundrying, 2.00 per cent tamarind solution, 5.00 per cent lime solution and 2.00 per cent sodium chloride, respectively. On 6th DAT, more than 50.00 per cent mortality was recorded in all treatments except 2.00 per cent sodium chloride and 5.00 per cent lime solution. On 7th DAT, cent per cent mortality was recorded in SFEC treated seeds while tap water washing, sundrying, 2.00 per cent sodium bicarbonate, 2.00 per cent tamarind solution, hot water washing, 2.00 per cent sodium chloride and 5.00 per cent lime solution recorded 95.50, 88.90, 73.30, 70.00, 62.20, 66.60 and 46.60 per cent mortality respectively. Among different decontamination treatments, 5.00 per cent lime solution showed least mortality per cent. Hence, 5.00 per cent lime solution can be considered as the best decontamination treatment.

Discussion

In green gram seeds, cent per cent mortality was recorded at sweet flag EC formulation treated seeds (without decontamination) while it was 50.00, 44.00, 39.00, 39.00, 33.00, 17.00 and 12 per cent in tap water washing, sundrying, hot water washing. 2.00 per cent sodium bicarbonate, 2.00 per cent tamarind solution, 2.00 per cent sodium chloride and 5.00 per cent lime solution respectively on 4th DAT. On 7th DAT, it was 95.50, 88.90, 73.00, 70.00, 66.00, 62.00 and 46.60 per cent in tap water washing, sundrying, 2.00 per cent sodium bicarbonate, 2.00 per cent tamarind solution, hot water washing, 2.00 per cent sodium chloride and 5.00 per cent lime solution respectively. Mortality indicated the insecticidal action of sweet flag EC formulation after decontamination of sweet flag EC on green gram seeds. Among different decontamination techniques 5.00 per cent lime solution showed lowest (46.60 per cent) mortality, which indicated that lime solution was efficient to remove the residues of sweet flag EC formulation on green gram seeds.

In maize seeds, 72.20 per cent mortality was recorded at sweet flag EC formulation treated seeds (without decontamination) while it was 11.07, 8.87, 7.77, 6.63, 4.40, 3.33 and 00.00 per cent in 2 per cent tamarind solution, tap water washing, sundrying, hot water washing. 2.00 per cent sodium chloride, 2.00 per cent sodium bicarbonate and 5.00 per cent lime solution respectively on 4th DAT. On 7th DAT, the mortality was 12.20, 11.10, 10.00, 10.00, 10.00, 6.67 and 1.10 per cent in 2.00 per cent tamarind solution, 2.00 per cent sodium chloride, tap water washing, sundrying, hot water washing, 2.00 per cent sodium bicarbonate and 5.00 per cent lime solution. Among different decontamination agents tested 5 per cent lime solution showed lowest (1.10%) mortality which indicated that the lime solution has the ability to remove the sweet flag extracts adhering with the maize seeds. There was variation in the mortality of *S. oryzae* and *C. maculatus*, when the seeds were decontaminated with 5 per

cent lime solution. The concentration of the active principle of beta asarone in the decontaminated seeds has to be analysed in the future.

Though there was no report on decontamination techniques for botanical insecticides from food commodities, residues of monochrotophos, fenitrothion and fenvalerate were removed to an extent of 41.81, 100.00 and 100.00 per cent by dipping in 2 per cent lemon juice, dipping in 2 per cent tamarind solution for 5 min followed by washing with tap water and steam cooking for 10 min, respectively [8]. Removal of malathion residues by cooking with and without 2 per cent sodium chloride was 56.7 and 69.7 per cent, respectively in maize grains and 64.2 and 75.1 per cent, respectively in beans [7]. Washing with tap water for 5 min, followed by steaming the concentration of bromide, chlorpyrifos-methyl, dichlorvos, fenitrothion and malathion residues were reduced from 49.0 to 61-99 per cent, respectively in boiled rice and rice noodles [10] and chlorpyriphos residues removed in vegetables by washing with water was 42.00 to 89.00 per cent [14].

Residues of malathion, chlorpyriphos, quinalphos, profenophos and cypermethrin, (54.46 - 73.25 and 54.38 - 68.24 per cent, respectively) were removed by dipping of okra fruits in tamarind solution (2 per cent) and common salt solution (2 per cent) for 15 minutes, followed by washing in tap water on after one day of spraying [9].

Table 1: Evaluation of decontamination techniques for Sweet Flag Emulsifiable Concentrate (SFEC) formulation in terms of insecticidal action on *S. oryzae* in maize seeds

Treatments	Cumulative adult mortality (%)						
	1DAT	2 DAT	3 DAT	4 DAT	5 DAT	6 DAT	7 DAT
T1-Sundrying	1.10 (6.01)^{d}	4.47 (12.2)^{c}	6.67 (14.86)^{c}	7.77 (16.12)^{cd}	8.87 (17.32)^{c}	10.00 (18.43)^{bc}	10.00 (18.43)^{c}
T2- Tap water washing	1.10 (6.01)^{d}	3.33 (10.51)^{d}	6.67 (14.96)^{c}	8.87 (17.32)^{c}	9.97 (18.40)^{bc}	10.00 (18.43)^{bc}	10.00 (18.43)^{c}
T3- Hot water washing	1.10 (6.01)^{b}	4.47 (12.20)^{c}	6.67 (14.96)^{c}	6.63 (14.91)^{d}	6.67 (14.96)^{d}	7.80 (16.21)^{cd}	10.00 (18.43)^{c}
T4-2% Nacl	2.20 (8.52)^{c}	2.23 (8.57)^{e}	3.30 (10.46)^{d}	4.40 (12.10)^{e}	6.67 (14.96)^{d}	6.70 (14.99)^{d}	11.10 (19.48)^{bc}
T5-2% tamarind solution	2.20 (8.52)^{c}	7.77 (16.18)^{b}	11.10 (19.45)^{b}	11.07 (19.52)^{b}	12.20 (20.44)^{b}	12.20 (20.43)^{b}	12.20 (20.43)^{b}
T6-2% $NaHCO_3$	0.00 (0.43)^{e}	0.00 (0.43)^{f}	0.00 (0.43)^{e}	3.33 (14.96)^{e}	6.67 (14.96)^{f}	6.67 (14.96)^{e}	6.67 (14.96)^{e}
T7-5% Lime solution	0.00 (0.43)^{e}	0.00 (0.43)^{f}	0.00 (0.43)^{e}	0.00 (0.43)^{f}	1.10 (6.01)^{e}	1.10 (6.01)^{e}	1.10 (6.01)^{d}
T8 Control- (SFEC Treated)	4.33 (10.41)^{a}	23.33 (28.87)^{a}	47.78 (42.72)^{a}	72.00 (58.41)^{a}	80.00 (63.41)^{a}	87.78 (69.53)^{a}	93.3 (75.13)^{a}
T9- Standard check (without SFEC)	0.00 (0.43)^{e}	0.00 (0.43)^{g}	0.00 (0.43)^{e}	0.00 (0.43)^{f}	0.00 (0.43)^{f}	0.00 (0.43)^{f}	0.00 (0.43)^{e}
SEd	0.21	0.28	1.35	0.83	0.64	0.651.08	1.08
CD (0.05)	0.45	0.58	2.84	1.74	1.36	1.382.28	2.28

Values are mean of three replications
DAT = Day(s) after treatment
Figures in parentheses are transformed arcsine values
In a column means followed by same letter(s) are not significantly different (p=0.05) by LSD

Table 2: Evaluation of decontamination techniques for Sweet Flag Emulsifiable Concentrate (SFEC) formulation in terms of insecticidal action on *C. maculatus* in green gram seeds

Treatments	Cumulative adult mortality (%)						
	1DAT	2 DAT	3 DAT	4 DAT	5 DAT	6 DAT	7 DAT
T1-Sundrying	8.00 (16.42)^{c}	11.10 (19.45)^{d}	21.00 (27.27)^{c}	44.00 (41.44)^{c}	67.77 (55.41)^{b}	85.50 (67.62)^{b}	88.90 (70.66)^{c}
T2- Tap water washing	12.00 (20.26)^{b}	15.53 (23.20)^{c}	30.00 (33.20)^{b}	50.00 (44.09)^{b}	59.77 (50.63)^{c}	80.00 (63.47)^{c}	95.50 (77.76)^{b}
T3- Hot water washing	7.00 (15.33)^{c}	10.00 (18.43)^{e}	24.00 (29.33)^{d}	39.00 (38.64)^{d}	47.73 (43.69)^{e}	57.70 (49.42)^{d}	66.60 (54.70)^{ef}
T4-2% Nacl	0.00 (0.43)^{f}	2.20 (8.52)^{g}	11.00 (19.38)^{h}	17.00 (24.34)^{f}	25.53 (30.45)^{g}	43.30 (41.11)^{f}	62.20 (52.26)^{f}
T5-2% tamarind solution	2.00 (8.12)^{e}	9.97 (18.40)^{e}	18.00 (25.1)^{e}	33.00 (35.06)^{e}	43.27 (41.13)^{f}	53.30 (46.89)^{e}	70.00 (56.78)^{de}
T6-2% $NaHCO_3$	7.00 (15.33)^{d}	18.87 (25.60)^{b}	22.00 (27.96)^{d}	39.00 (38.64)^{d}	52.20 (46.26)^{d}	60.00 (50.76)^{d}	73.30 (58.89)^{d}
T7-5% Lime solution	2.00 (8.12)^{e}	5.53 (13.59)^{f}	12.00 (20.30)^{g}	12.00 (20.26)^{g}	18.83 (25.71)^{h}	40.00 (39.22)^{g}	46.60 (43.05)^{g}
T8 Control- (SFEC Treated)	8.78 (17.32)^{a}	20.22 (26.56)^{a}	44.56 (41.80)^{a}	73.33 (58.91)^{a}	81.11 (68.41)^{a}	91.11 (82.41)^{a}	100.00 (89.41)^{a}
T9- Standard check (without SFEC)	0.00 (0.43)^{f}	0.00 (0.43)^{h}	0.00 (0.43)^{i}	0.00 (0.43)^{h}	0.00 (0.43)^{i}	0.00 (0.43)^{h}	0.00 (0.43)^{h}
SEd	0.30	0.40	0.27	0.43	0.80	0.71	1.72
CD (0.05)	0.63	0.85	0.57	0.91	1.68	1.50	3.62

Values are mean of three replications
DAT = Day(s) after treatment
Figures in parentheses are transformed arcsine values
In a column means followed by same letter(s) are not significantly different (p=0.05) by LSD

Conclusion

In the study to evaluate the decontamination techniques for sweet flag EC in terms of insecticidal action on *C. maculatus* in green gram seeds and *S. oryzae* in maize seeds, lowest mortality of *C. maculatus* (46.60 per cent) and *S. oryzae* (1.10 per cent) was observed in decontamination with lime solution (5.00 per cent) while 100.00 and 72.2 per cent mortality was observed in sweet flag EC without decontamination which indicated that lime solution could remove the sweet flag EC formulation from the green gram and maize seeds.

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