MANAGEMENT OF PESTICIDE RESIDUES IN SELECT SPICES

by

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THESIS

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2016

DECLARATION

I, hereby declare that this thesis entitled **"MANAGEMENT OF PESTICIDE RESIDUES IN SELECT SPICES"** is a bonafide record of research work done by me during the course of research and the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, of any other University or Society.

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LIST OF ABBREVATIONSAND SYMBOLS USED

@	At the rate of
^0C	Degree Celsius
%	Per cent
µL	Micro litre
CD	Critical difference
CRM	Certified Reference Material
cm	Centimetre
DDT	Dichloro Diphenyl Trichloroethane
DF	Dilution factor
ECD	Electron Capture Detector
et al.	And others
g	Gram
$g\ L^{-1}$	Gram Per litre
GC	Gas Chromatography
GOK	Govt. of Kerala
h	Hour
HCB	Hexachlorobenzene
HCH	Hexachlorocyclohexane
i. e.	That is
KAU	Kerala Agricultural University
Kg	Kilogram
$Kg\ ha^{-1}$	Kilogram per hectare

L	Litre
L^{-1}	Per litre
LOD	Limit of Detection
LOQ	Limit of Quantification
mg	Milligram
mL^{-1}	Per millilitre
MRL	Maximum Residue Limit
MRM	Multi residues Methods
NaCl	Sodium Chloride
ppm	Parts per million
RSD	Relative Standard Deviation
SD	Standard Deviation
viz.	Namely

Introduction

1. INTRODUCTION

Spices are parts of plants used to improve the flavour, acceptability and the appetizing property of food. India, the "land of spices" is the world's largest producer, consumer and exporter of spices. Around 52 spices are cultivated in India which generates a lot of foreign exchange. Prominent spices that are included in the Kerala cuisine are black pepper, cardamom, ginger, fennel, chilli, clove, coriander, cumin seed and peppermint leaves (Singh *et al.,* 2012).

One of the major factors which hamper productivity and yield of spices is its susceptibility to insect and disease attack. Apart from field infestation, storage pests are also a problem in spices (Abou-Arab and Donia, 2001) and it badly affects its quantity as well as quality. At present, these pests are kept under check with the steady use of insecticides. Organophosphates and synthetic pyrethroids are the widely used insecticides in spices production. Pesticide residues have been found in variable extent in spices; both raw and processed, as the pesticides are widely used in their production and storage. These pesticides will not disappear all of a sudden; it is likely to remain as residue on treated surface which in turn can reach the consumers during consumption of treated food materials.

The results of the Annual Plan Scheme " Production and Marketing of Safe to Eat Vegetables" funded by Department of Agricultural Development and Farmer's Welfare, Government of Kerala revealed the presence of pesticide residues in spices *viz.,* pepper mint leaf (78.94 per cent), curry leaf (57.14 per cent), chilli (35 per cent), coriander leaf (25 per cent), curd chilli (40 per cent), cumin seed (28.50 per cent), chilli powder (27 per cent) and dry chilli (20 per cent) samples collected from Thiruvananthapuram district (GOK, 2014). Chlorpyriphos, ethion, cypermethrin, fenvalerate, profenophos, dimethoate and quinalphos residues were frequently identified in these samples.

Management of pesticide residues in food commodities can be done either at pre harvest stage by creating awareness among choice, dose and frequency of pesticide application or by adopting organic farming or at post harvest stage by different processing methods (Nair *et al.,* 2012). Hence it is necessary to adopt simple household techniques to address pesticide residues.

The localization of pesticides in foods varies with the nature of pesticide molecule, type and portion of food material and environmental factors. The spices treated with pesticides contain unpredictable amount of these chemicals, hence there is a need to develop methodologies to dislodge pesticide residues from spices. Therefore, it is necessary to evaluate simple, cost effective strategies adoptable by consumers to enhance food safety from harmful pesticides. Household food processing techniques such as peeling, cooking as well as washing with water and various chemical solutions leads to large reductions in residue levels (Kaushik *et al.*, 2009). Several decontamination studies have been reported in vegetables while the studies related to decontamination of spices were meagre. Hence it necessitates the evaluation of simple, cost effective household techniques in the management of pesticide residues in spices.

In this context, the present study was undertaken with the objective to standardize household techniques to decontaminate pesticide residues in select spices.

Review of Literature

2. REVIEW OF LITERATURE

Spice constitutes a major group of agricultural commodity which are virtually indispensable in India's culinary art. India is the largest producer, consumer and exporter of spices and spice products. More than 90 per cent of the spices produced in the country were used for domestic consumption and only rest is exported (Nybe *et al.*, 2008).

Infestation by insect pest is a major factor responsible for the low productivity of spices in India. The indiscriminate and repeated uses of conventional insecticides accumulate the toxic pesticide residues on agricultural produce and poses serious threat to human health. Since spices are an important ingredient in Kerala cuisine, decontamination of pesticide residue in spices is very essential.

Study was conducted to standardise the decontamination techniques to remove the pesticide residues in peppermint leaves, coriander leaves, ginger, red chilli, cumin seed and fennel. The earlier works are reviewed here.

2.1 PESTICIDE RESIDUES IN SPICES

2.1.1 Peppermint Leaves

Peppermint is herbaceous plant which is indigenous to Europe but it is widespread cultivated throughout the world. Flea beetles, leafhoppers, lygus bugs, mint leaves beetles, tortoise beetles and tortrix moths are the insect pests causing damage to the spices. Pesticides were applied to protect the crop from harmful insects and other pests, but risk is associated with each use of pesticides due to the possibility of leaving residues on harvested crops (Szpyrka, 2012). Dogheim *et al.* (1996) reported that *Mentha* spp collected from shipments, were highly contaminated with HCH (0.27 mg kg^{-1}), pirimiphos-methyl (0.12 mg kg^{-1}), dimethoate (1.14 mg kg^{-1}) and HCB (0.61 mg kg^{-1}). Results of the project "Production and Marketing of Safe to Eat Vegetables, Govt. of Kerala" revealed that 78.94 per cent of peppermint leaves collected from Thiruvanthapuram region showed the presence of residues of insecticides *viz.,* (profenophos , chlorpyriphos and ethion) (GOK,2014).

2.1.2 Coriander Leaves

Coriander (*Coriandrum sativum* L.) is an important spice crop consumed all over the world and India leads in its production (Nazeem, 1995). Its aromatic leaves and seeds are used as spice for flavouring various dishes. Among the insect pests, coriander green aphid, *Hyadaphis coriandari* (Das) is the most important pest causing significant loss in yield. Methyl demeton (0.05 ppm), malathion (0.04 ppm) and fenvalerate (0.01 ppm) were the pesticides commonly reported from the market samples of coriander (Bhanot *et al.,* 2002) and the residues of aldrin, dieldrin, heptachlor and lindane were detected from West Bengal (Kumar *et al.,* 2012). Coriander leaves showed higher residues when compared to that of seeds (Bandral and Sharma, 2007). Chlorpyriphos, quinalphos , profenophos and ethion were the commonly detected insecticides in the coriander leaves collected from Thiruvanthapuram region (GOK, 2014).

2.1.3 Chilli

Chilli (*Capsicum annuum* L.) is an indispensable spice used as basic ingredient in everyday cuisine all over the world. The attack of pest complex in chilli at different stages is the major constrain in its cultivation. More than 293 insects and mite species were reported in chilli in the field as well as in storage (AVRDC, 1987). High yield losses due to insects can be managed only by insecticide application. The major class of insecticides which were commonly used in chilli includes organochlorines, organophosphates and synthetic pyrethroids. Residues of ethion, triazophos, chlorpyriphos, phosphamidon, cypermethrin, fenvalerate and dicofol have been reported by various workers in India (Awasthi *et al.*, 2001, Sreenivasa Rao, 2005). Green chilli, red chilli (dry) as well as chilli powder from Thiruvanthapuram markets were found to be contaminated with profenophos, bifenthrin, lambda cyhalothrin and ethion (GOK, 2014).

2.1.4 Cumin Seed and Fennel

In a monitoring study carried out by Abou-Arab (1999), pesticide residues of malathion, profenophos, DDT and dimethoate were detected in 303 samples of cumin seed and fennel. Srivastava *et al.* (2001) reported that, residues of DDT (0.055 mg kg^{-1}) and HCH (0.0467 mg kg^{-1}) were detected in cumin seed collected from the local markets of Lucknow and residues of both malathion (4.1 mg kg^{-1}) and diazinon (7.6 mg kg^{-1}) were also detected in cumin seed samples collected from Iran (Sarkhail *et al.,* 2012).

Among the spices monitored for pesticide residues from Thiruvanthapuram district of Kerala, cumin seed had detectable level of chlorpyriphos (0.04-0.27 mg kg^{-1}), profenophos (0.48-1.45 mg kg^{-1}), quinalphos (0.139 mg kg^{-1}) and endosulphan (0.115-0.135 mg kg^{-1}) (GOK, 2014). In different spices profenophos was the insecticide detected maximum from cumin seed exceeded 4 per cent of ADI value, which was considered as a margin indicating chronic health risk (Nair *et al.,* 2013).

2.1.5 Ginger

Ginger (*Zingiber officinale*) is a perennial herb whose underground rhizomes, are used as spice. Pesticide contamination was less in ginger compared to other spices, however, quinalphos was the only pesticide detected from the market sample (GOK, 2014).

2.2 DECONTAMINATION OF PESTICIDE RESIDUES THROUGH DIFFERENT HOUSEHOLD PRACTICES

Different food processing techniques at household level can be effectively applied on agricultural commodities to minimize the risk of pesticides on human health. Several researchers reported the thorough processing of fruits and vegetables including washing, peeling, cooking etc reduced the residues considerably. But the efficiency of food processing techniques depends on factors like physicochemical properties of both the pesticide and the commodity, age of the residue etc. Thus, for the removal of residues from food commodities were subjected to physical process like washing or peeling, acid or base hydrolysis and thermal degradation (Chin, 1991).

2.2.1 Washing

Washing is the most common process done initially in household and commercial preparations. A reasonable amount of loosely held residues on the surface of agricultural commodities can be removed by varied types of washing processes (Street, 1969). Effectiveness of washing depends upon the physiochemical properties of the pesticides such as water solubility, hydrolytic rate constant, volatility and octanol water partitioning coefficient (P_{ow}) in conjunction with the actual physical location of the residues, age of residues, temperature and type of washing (Cengiz *et al.*, 2007).

Although both organophosphate and synthetic pyrethroid residues were decreased by tap water washing (Dikshit *et al.*, 2002), the extent of removal was not complete, as pesticide residues after spraying rapidly penetrate into the commodities.

Dikshit (2001) reported that rice treated with cypermethrin, when subjected to five washings resulted in 37 to 49 per cent removal of residues. Similarly, washing of potato by dipping in water for 10 minutes reduce 70.70 to 75.30 per cent of organophosphorous and organochlorine insecticides residues (Soliman, 2001).

Washing of cow pea in water brought about a reduction of 79.39 per cent of emamectin benzoate residues. This reduction was probably on account of dissolution of emamectin benzoate in water (Vijayasree *et al.*, 2014). Washing of amaranthus thrice with water after dipping for ten minutes in tap water reduced 37.37 to 80.50 per cent of the initial residues of dimethoate, malathion, chorpyriphos, quinalphos, profenophos, ethion, bifenthrin and lamda cyhalothrin. These results suggested that a part of sprayed pesticides remain as microparticles on the surface of the amaranthus and were easily removed by mechanical stirring in water (Muralikrishna, 2015).

The effect of washing on removal of pesticide residues in different agricultural commodities are reviewed in Table 1.

2.2.2 Cooking

Cooking is the household process of preparing food by the application of heat and a vast range of cooking methods are practiced depending on the customs and traditions, availability and the affordability of the resources (Kaushik *et al.*, 2009). By this process, a great reduction in pesticide residues lower than the Maximum Residue Limits (MRLs) was observed.

Soliman (2001) conducted a study to assess the effect of cooking on the removal of pesticide residues from vegetables. He observed that cooking removed organophosphate than organochlorine insecticides, as the percentage reduction of organophosphate insecticides ranged from 49 to 53 per cent at 100°C and reduction of 30.10 to 35.30 per cent for the organochlorines. Gill *et al.* (2001) reported that alphamethrin residues reduced appreciably on cooking in the range of 25 to 32 per cent in brinjal and tomatoes and 12 to 17 per cent in cauliflower.

Radwan *et al.* (2005) studied the effectiveness of cooking in reducing the pesticide residues from vegetables. The results showed that, organochlorine insecticides were reduced in the range of 39 to 55 per cent in brinjal, 57 to 61 per cent in cauliflower and 32 to 47 per cent in okra. Reduction to an extent of 37, 40 and 42 per cent of synthetic pyrethroid insecticides was observed in brinjal, cauliflower and okra, respectively. Among organophosphate insecticides, reduction was 100 per cent in brinjal, 92 per cent in cauliflower and 75 per cent in okra.

Balinova *et al.* (2006) explained the disappearance of pesticide residues during cooking processes by volatilization, hydrolysis and thermal breakdown at elevated temperature.

Zhang *et al.* (2007) reported that stir-frying of cabbage in a pan at 100°C for five minutes, removed 86.00 per cent of endosulphan residue. Kumari (2008) reported that boiling reduced 100 per cent, 92 per cent and 75 per cent of organophosphates residues in brinjal, cauliflower and okra respectively.

Removal of residue removal depends on the mode of cooking *i.e.*, cooking under closed conditions resulted in hydrolysis with 50 per cent of the chlorothalonil being recovered unchanged on the crop and hydrolysis product being found in the liquor. Cooking of rice in the pressure cooker, microwave oven and open vessel showed 10.60 per cent, 27.35 per cent and 49.20 per cent loss in case of lambda cyhalothrin and 11.30 per cent, 54.40 per cent and 71.50 per cent loss in case of deltamethrin respectively (Rahula and Shah, 2008).

In a study conducted by Yang *et al.* (2012), the complete pesticide removal (100 per cent) was observed in ginger by cooking, boiling, stir-frying, and blanching.

The effect of cooking on removal of pesticide residues in different agricultural commodities are reviewed in Table 2

Table 1: Studies on effects of washing on removal of pesticide residues from different agricultural commodities

Sl. No	Commodity	Type of treatment	Pesticides	Removal (%)	Reference
1	Apple	Washing by hand rubbing	Chlorpyriphos	17.00 - 21.00	Kong *et al.*, 2012
			Cypermethrin	6.70 - 7.10	Chavarri *et al.*, 2005
			Acetamiprid	42.00 - 67.00	
2	Bell pepper	Washing with running tap water	Parathion	37.00	Satpathy, 2012
			Methyl parathion	36.00	
			Malathion	40.00	
			Fenitrothion	34.00	
			Formothion	27.00	
			Chlorpyriphos	31.00	
3	Bittergourd	Washing with water	Profenophos	46.34	Mirani *et al.*, 2013
			Bifenthrin	43.64	
4	Brinjal	Washing with running tap water (five minutes)	Organo Phosphates	77.00	Kumari, 2008
			Organo Carbamate	27.00-44.00	
			Synthetic Pyrethroids	26.00	

	Brinjal	Washing with water	Cypermethrin	33.42-35.00	Kaur *et al.*, 2011
			Deltamethrin	25.00-27.90	
6	Cabbage	Washing with water	Chlorantraniliprole	17.00-40.00	Kar *et al.*, 2012
7	Carrot	Simple washing with water for five minutes	Chlorpyriphos	60.00	Randhawa *et al.*, 2007
8	Cauliflower	Washing 30 seconds under tap water(25-30°c)	Monocrotophos	70.00	Thanki *et al.*, 2012
			Phorate	16.00	
			Parathion	48.26	
			Pendimethalin	27.38	
			Cypermethrin	24.47	
			Endosulphan	33.26	
9	Chilli	Washing with tap water	Spiromesifen	58.86	Varghese, 2011
10	Cucumber	Washing with tap water	Malathion	65.60	Raveendranath, 2014
			Profenphos	41.23	
			Quinalphos	60.14	

11	Curry leaf	Dipping in water for 15 minutes	Malathion	25.88	Nair *et al.*, 2014
			Chlorpyriphos	10.80	
			Quinalphos	18.59	
			Profenophos	21.66	
			Cypermethrin	8.19	
12	Garlic	Washing with normal water	Chlorpyriphos	3.65	Ling *et al.*, 2011
13	Maize	Washing with distilled water for one minute	Malathion	35.70	Lalah and Wandiga,2002
14	Okra	Washing with normal water for 10 minutes	Deltamethrin	42.06	Parmar *et al.*, 2012
			Alphamethrin	26.32	
			Triazophos	41.75	
			Ethion	50.28	
			Cypermethrin	26.32	
		Simple washing with water	Chlorpyriphos	13-35	Tomer and Sangha, 2013
			Cypermethrin	45-50	

	Okra	Dipping in water for 15 minutes	Malathion	37.67	Nair *et al.,* 2014
			Chlorpyriphos	9.48	
			Quinalphos	33.24	
			Profenophos	23.64	
			Cypermethrin	6.70	
15	Potato	Washing with water	Primphos-methyl	12.90	Zohair, 2001
16	Tomato	Washing with water (thrice)	Lufenuron	29.71	Mirani *et al.,* 2013
		Washing with tap water	Dimethoate	48.00	Vemuri *et al.*, 2014
			Methyl parathion	50.00	
			Quinalphos	52.00	
			Endosulphan	53.00	
			Profenophos	47.07	

Table 2: Studies on effects of cooking on removal of pesticide residues from different agricultural commodities

Sl. No	Commodity	Type of treatment	Pesticides	Removal (%)	Reference
1	Beans	By using microwave for 15 to 45 minutes	Trifluralin	92 .00– 99.00	Castro *et al.*, 2002
			Chlorpyriphos		
			Decamethrin		
			Cypermethrin		
			Dichlorovos		
		Cooking	Malathion	56.70	Lalah and Wandiga, 2002
2	Bittergourd	Frying	Bifenthrin	93.41	Sheikh *et al.*, 2013
			Profenophos	88.68	
		Plain washed dehydrated fried	Profenophos	89.47	Mirani *et al.*, 2013
		Detergent washed dehydrated fried		90.35	
3	Brinjal	Washing followed by steam cooking	Triazophos	64.00 – 88.00	Reddy *et al.*, 2001
			Lindane	42.00 – 56.00	

	Brinjal	Washing followed by cooking for five minutes	Quinalphos	28.2-69	Samanta, 2006
			Methomyl	44.4-76.1	
			Cypermethrin	40-70.2	
		Washing for five seconds followed by cooking for 10-12 minutes	Chlorpyriphos	28.00	Randhawa *et al.*, 2007
		Cooking in oil	Cypermethrin	45.20	Walia *et al.*, 2010
		Cooking in water		41.10	
		Boiling	Chlorpyriphos	39.8	Ling *et al.*, 2011
		Washing followed by boiling	Endosulfan	72	Chauhan and Kumari, 2011
			Cypermethrin	31.00 – 42.00	Kaur *et al.*, 2011
			Deltamethrin	26 .00– 37.00	
		Boiling	Parathion	96.5	Satpathy, 2012
			Methyl parathion	884	

	Brinjal	Direct cooking	Dimethoate	56.41	Vemuri *et al.*, 2015
			Methylparathion	58.00	
			Quinalphos	58.20	
			Endosulphan	61.00	
			Profenophos	59.00	
4	Broccoli	Washing followed cooking	Chlorpyriphos	61.6	Lozowicka and Jankowska, 2014
5	Cabbage	Washing followed by boiling in water for 20 minutes	Diazinon	80-90	Kang and Lee, 2005
			Dichlorovos		
		Stir – frying for five minutes	Chlorpyriphos	86.60	Zhang *et al.*, 2007
			p,p-DDT	67.50	
			Cypermethrin	84.70	
			Chlorothalonil	84.80	
		Boiling	Chlorpyriphos	55.50	Ling *et al.*, 2011

6	Capsicum	Boiling	Organophosphates	61 - 84	Satpathy, 2012
		Cooking in open pan for 10 minutes	Fipronil	65.68	Xavier *et al.*, 2014
7	Cauliflower	Cooking	Chlorpyriphos	29.00	Zhang *et al.*, 2007
		Boiling	Organophosphates	92	Kumari, 2008
		Cooking for 10-15 minutes	Monocrotophos	70.67	Thanki *et al.*, 2012
			Parathion	70.26	
			Pendimethalin	59.82	
		Boiling	Parathion	96.5	Satpathy, 2012
			Methyl parathion	884	
			Malathion	93.9	
			Fenitrothion	100	
			Formothion	96.7	
		Boiling for five minutes in water	Chlorantraniliprole	100	Kar *et al.*, 2012

8	Cucumber	Boiling	Chlorpyriphos	20.0	Ling *et al.*, 2011
		Frying		5.13	
		Cooking under micro wave		5.88	
		Washing followed cooking	Quinalphos	83.05	Raveendranath *et al.*, 2014
			Profenophos	73.06	
9	Okra	Steaming	Organophosphates	75	Kumari, 2008
		Boiling	Fenazaquin	38.00 – 40.00	Duhan *et al,* 2010
			Chlorpyriphos	64.00 – 77.00	Samriti and kumari, 2011
			Emamectin benzoate	35.0	Sheikh *et al.*, 2012
		Cooking	Deltamethrin	76.64	Parmar *et al.*, 2012
			Alphamethrin	46.62	
			Triazophos	66.34	
10	Tomato	Washing followed by cooking	Alphamethrin	11.00 – 30.00	Kanta *et al.*, 2001

		Washing followed by steaming	Lambda cyhalothrin	60.00 – 69.00	Jayakrishnan *et al.*, 2005
		Boiling	Chlorpyriphos	75.90	Ling *et al.*, 2011
		Frying		10.30	
		Cooking under micro wave		67.20	
		Washing followed by cooking	Bifenthrin	42.10 – 45.23	Chauhan *et al.*, 2012
		Boiling	Parathion	64.1	Satpathy, 2012
			Methyl parathion	68.9	
			Malathion	71	
			Fenitrothion	76	
			Formothion	84.1	
			Chlorpyriphos	76.8	

2.2.3 Chemical solutions

Acidic or alkaline washing solutions such as chlorine solution, ozonated water and strong acid were found to be effective in minimizing the pesticide residues in food crops (Ong *et al.,* 1996; Zohair, 2001; Pugliese *et al.,* 2004). Chemicals such as salt, baking soda, distilled vinegar and potassium permanganate were also recommended for the purpose of removing pesticide residues (ETN, 1996).

Washing food commodities with solutions readily available in house hold kitchen had an additive advantage over plain water washing (Krol *et al.,* 2000). Higher removal of residues were noticed in acidic solutions compared to neutral and alkaline solutions, thus dipping in acidic solutions like acetic acid for 10 minutes resulted in significant reduction of pesticide residues (Wheeler, 2002).

Radwan *et al.* (2005) studied the effectiveness of washing with acetic acid two per cent in reducing the pesticide residues from sweet pepper. The results showed that, 85.48 per cent removal of profenophos residues was obtained when washed with acetic acid. Cabbage when processed with different levels of acetic acid solution gave 51.30 per cent, 47.01 per cent, 33.70 per cent, 91.50 per cent, 86.0 per cent and 93.7 per cent loss in chlorpyriphos, p,p- DDT, cypermetrin and chlorothalonill respectively (Zang *et al.*, 2007) .

Several studies proved the efficacy of sodium chloride (NaCl) solution in dislodging the pesticide residues from different fruits and vegetables. Concentration of solutions were positively co related with the the percentage reduction in pesticide residues. In grape berries, the residues of endosulphan and quinalphos were reduced upto 67.52 per cent and 51.77 per cent respectively by soaking berries in two per cent salt water for 10 minutes followed by washing with water (Reddy and Rao, 2002). A notable effect was noticed by washing with two per cent salt water when compared with other methods and the efficiency depends on the nature of the food commodity. Dipping in two per cent tamarind solution for 15 minutes followed by washing in tap water resulted in 68 to 75 per cent and 70 to 88 per cent of methyl parathion, malathion, chlorpyriphos, quinalphos, profenophos, ethion, cypermethrin and fenvalerate in okra and curry leaves respectively (Nair *et al.*, 2013).

The effect of different chemicals on removal of pesticide residues in different agricultural commodities are reviewed in Table 3.

2.2.4 Peeling

Peeling is an important step in the processing of most fruits and vegetables. Majority of the insecticides applied directly to crops confined to the outer surfaces where they are amenable to removal in peeling, hulling or trimming operations. Peeling completely removes the residues from fruits such as avocado, bananas, citrus, kiwifruit, mango and pineapple (Toker and Bayindirli, 2003). Randhawa *et al.* 2007 reported that peeling of tomato and brinjal significantly reduced the residues as their thick and smooth surface prevents the penetration of insecticides into the fruits.

Residues which were not removed by washing in cucumber can be removed easily by the removal of the skin by peeling resulting in reduction of diazinon and malathion residues by more than 45.90 and 60.60 per cent (Dehghan *et al.*, 2010). The effect of peeling on removal of pesticide residues in different agricultural commodities are reviewed in Table 4.

Table 3: Studies on the effects of different solutions on removal of pesticide residues from different agricultural commodities

Sl. No	Commodity	Type of treatment	Pesticides	Removal (%)	Reference
1	Beans	NaCl	Malathion	59.00	Lalah and Wandiga, 2002
2	Bitter gourd	Dipping in two per cent salt water for one hour	Monocrotophos	90.00	Kumar, 1997
3	Brinjal	Acetic acid two per cent	Profenophos	100.00	Radwan *et al.*, 2005
		Sodium chloride one per cent		97.41	
		Dipping in two per cent common salt for 20 minutes	Chlorantraniliprole	82.45 – 90.66	Vijayasree *et al.*, 2015
		Dipping in two per cent tamarind for 20 minutes		77.47 – 79.96	
		Dipping in two per cent vinegar for 20 minutes		76.32 – 100	
		Dipping in one per cent turmeric for 20 minutes		86.52 – 88.79	
4	Cabbage	Two per cent NaCl solution for five minutes	Chlorpyriphos	15.96	Zhang *et al.*, 2007
			p,p- DDT	23.07	
			Cypermethrin	10.68	

5	Capsicum (Hot pepper)	Acetic acid two per cent	Profenophos	60.61	Radwan *et al.*, 2005
		Sodium chloride one per cent		79.85	
6	Capsicum (Sweet pepper)	Acetic acid two per cent		85.48	
		Sodium chloride one per cent		74.84	
7	Capsicum	Dipping in two per cent tamarind for 15 minutes	Organo phosphates	24.84 – 34.42	Nair, 2013
			Synthetic pyrethroids	37.73 – 39.35	
		Dipping in two per cent vinegar for 15 minutes	Organo phosphates	31.18 – 48.46	
			Synthetic pyrethroids	57.70 – 74.88	
		Dipping in one per cent turmeric for 15 minutes	Organo phosphates	17.07 – 22.71	
			Synthetic pyrethroids	16.52 – 21.64	

	Capsicum	Dipping in two per cent common salt for 15 minutes	Organophosphate	33.09 – 48.00	
			Synthetic pyrethroids	53.26 – 54.74	
8	Curry leaf	Dipping in two per cent tamarind for 15 minutes	Organophosphate	57.10 – 65.65	Nair *et al.*, 2014
		Dipping in two per cent vinegar for 15 minutes		41.77 – 52.77	
		Dipping in one per cent turmeric for 15 minutes		8.90 – 63.89	
		Dipping in two per cent common salt for 15 minutes		54.38 – 68.24	
9	Cow pea	Dipping in two per cent common salt for 20 minutes	Emamectin benzoate	85.56 – 100	Vijayasree *et al.*, 2014
			Spinosad	56.36 - 75.98	
		Dipping in two per cent tamarind for 20 minutes	Emamectin benzoate	100.00	
			Spinosad	66.19 – 83.50	

	Cowpea	Dipping in two per cent vinegar for 20 minutes	Emamectin benzoate	33.82 – 100	Vijayasree *et al.*, 2014
			Spinosad	50.79 – 75.69	
		Dipping in one per cent turmeric salt for 20 minutes	Emamectin benzoate	82.44 – 100	
			Spinosad	38.05 – 85.72	
10	Chilli	Dipping in two per cent salt solution for 10 minutes	Triazophos	32.50 - 84.21	Kumar *et al.*, 2000
			Acephate	78.95	
		Dipping in two per cent tamarind solution	Fipronil	96.10 – 97.88	Xavier *et al.*, 2014
		Dipping in two per cent vinegar solution		93.61 – 93.71	
		Dipping in one per cent turmeric solution		95.06 – 95.92	
11	Grapes	Dipping in two per cent common salt for 10 minutes	Quinalphos	50.00 – 51.77	Reddy *et al.*, 2001
			Chlorpyriphos	65.00 – 67.52	

12	Maize	NaCl	Malathion	71.20	Lalah and Wandiga, 2002
		NaCl solution	Organo chlorine	28.00 – 93.00	Wheeler, 2002
13	Okra	Dipping in two per cent tamarind for 15 minutes	Organo phosphorous	24.84 – 33.46	Nair *et al.*, 2014
		Dipping in two per cent vinegar for 15 minutes		38.67 – 63.76	
		Dipping in one per cent turmeric for 15 minutes		32.14 – 52.88	
		Dipping in two per cent common salt for 15 minutes		54.38 – 68.24	
		Dipping in two per cent common salt for 20 minutes	Chlorantraniliprole	50.94 – 77.04	Vijayasree *et al.*, 2013
		Dipping in two per cent tamarind for 20 minutes		47.78 – 64.86	
		Dipping in two per cent vinegar for 20 minutes		69.04 – 86.10	
		Dipping in one per cent turmeric for 20 minutes		75.66 – 84.33	

14	Potato	Acetic acid solution	Organo chlorine	18.20 – 65.30	Soliman, 2001
		NaCl solution		18.20 – 15.60	
		Acetic acid	Pirimophos methyl	100.00	Zohair, 2001
			Malathion	100.00	
			Profenophos	100.00	
15	Tomato	Saline solution	Lambda cyhalothrin	26.00 – 43.00	Jayakrishnan *et al.*, 2005
		Washing with two per cent salt solution	Dimethoate	78.00	Vemuri *et al.*, 2014
			Methylparathion	82.00	
			Quinalphos	91.30	
			Endosulphan	89.00	
			Profenophos	88.20	

Table 4: Studies on the effects of peeling on removal of pesticide residues from different agricultural commodities

Sl. No	Commodity	Pesticides	Removal (%)	Reference
1	Apple	Chlorpyriphos	65.80	Kong *et al.*, 2012
		Beta cypermethrin	11.50	
		Acephate	75.00	
2	Brinjal	Chlorpyriphos	75.00	Randhawa *et a*l., 2007
3	Cucumber	Diazinon	67.30-85.00	Cengiz *et al.*, 2007
		Malathion	45.90-60.01	Dehghan *et al.*, 2010
		Quinalphos	57.50	Raveendranath *et al.*, 2014
		Profenophos	65.39	

4	Potato	HCB	75.3	Soliman,2000
		Lindane	72.7	
		pp DDT	71.2	
		Chlorpyriphos	85	Randhawa *et al.*, 2006
5	Tomato	DDT	99	Street, 1969
		Carbaryl	92	
		HCB	42	Abou Arab, 1999
		Lindane	45.4	

Materials and Methods

3. MATERIALS AND METHODS

Laboratory and field experiments were conducted to standardize household techniques to decontaminate pesticide residues in spices like peppermint leaves, coriander leaves, red chilli, cumin seed, fennel and ginger. The experiments were carried out at Pesticide Residue Research and Analytical Laboratory (PRRAL), College of Agriculture, Vellayani during the period of 2014-2016.

The detailed materials and methods followed during the course of the work are mentioned below.

3.1 VALIDATION OF MULTI RESIDUE METHODS (MRM) FOR PESTICIDE RESIDUE ANALYSIS IN SPICES

Validation of Multi Residue Methods (MRM) for pesticide residue analysis for each substrate was conducted by modified Standard Method "AOAC 18^{th} edition 2007:2007.01".Validation parameters *viz.*, Limit of Detection (LOD), Limit of Quantification (LOQ), Linearity, Recovery and Repeatability (Zanella *et al.*, 2000) were evaluated for insecticides selected for the study (Table 5) under laboratory conditions at PRRAL, College of Agriculture, Vellayani.

Table 5: List of insecticides

SL No.	Common Name	Trade Name	Quantity required to prepare 25 ppm (mLL^{-1})
1	Dimethoate	Rogar 30 EC	0.08
2	Chlorpyriphos	Radar 20 EC	0.125
3	Quinalphos	Ekalux 25 EC	0.10
4	Profenophos	Curacron 50 EC	0.05
5	Ethion	Tafethion 35 EC	0.05
6	Bifenthrin	Talstar 10 EC	0.25
7	L- cyhalothrin	Karate 5 EC	0.50
8	Cypermethrin	Ralo 10 EC	0.10
9	Fenvalerate	Fenval 20 EC	0.125

3.1.1 Preparation of Standard Pesticide Mixture

Certified reference materials (CRM) of different pesticides *viz.,* dimethoate, chlorpyriphos, quinalphos, profenophos, ethion, bifenthrin, lambda cyhalothrin, cypermethrin and fenvalerate with purity ranging from 95.1 to 99.99 were purchased from M/s Sigma Aldrich and stored in freezer (Table 6). All the glass wares were washed with distilled water and laboline and rinsed with distilled acetone. These glass wares were then dried in hot air oven at 50° C for 3 h. All chemicals like sodium sulphate, sodium chloride and magnesium chloride were activated in hot air oven at 45 ^{0}C for 5 h.

Stock solutions (1000 mg kg^{-1}) of certified reference materials (CRM) of individual pesticide standards were prepared by dissolving weighed amount of each pesticide in a minimum quantity of distilled acetone and diluted with n-hexane: toluene (1:1).

Intermediate standards of 100 mg kg^{-1} of individual pesticide were prepared from the primary stock solution. It was prepared by mixing appropriate quantities of each pesticide stock solution and diluted accordingly.

Aliquots of intermediate standards of individual pesticide group (four organophosphates and five synthetic pyrethroids) were drawn in a separate volumetric flask to get separate working standard mixtures of each group at a concentration level of 10 mg kg^{-1}. Final volume was made up with n- hexane. From this, a working standard mixture of 10 mg kg^{-1} containing nine different pesticides were prepared and it was serially diluted to lower concentrations of 0.05, 0.075, 0.10, 0.25 and 0.50 mg kg^{-1}.

Table 6. List of Certified Reference Material (CRM) used in the preparation of pesticide mixture

Sl. No.	Pesticide group	Certified Reference Material	Purity (%)
1.	Organophosphates	Dimethoate	98.2
		Chlorpyriphos	99.9
		Quinalphos	99.2
		Profenophos	98.2
		Ethion	97.8
2.	Synthetic pyrethroids	Bifenthrin	98.3
		Cypermethrin	95.1
		Fenvalerate	98.7
		Lambda cyhalothrin	97.4

3.1.2 Standardization of Conditions of Gas Chromatograph (GC) and Determination of Limit of Detection (LOD)

The determination of pesticide residue was carried out by GC (Shimadzu 2010) equipped with ^{63}Ni Electron Capture Detector (ECD). The GC separations were performed with DB-5 capillary column (dimethyl polysiloxane, 30 m x 0.25 mm i.d. x 0.5µm film thickness). The operating temperatures were injector 250°C, ECD 300°C and oven temperature was programmed as follows: 170°C for 10 minutes, increased at the rate of 1.5°C/ minutes to 220°C for 10 minutes and then increased at the rate of 4°C/ minutes hold for seven minutes The ultra high pure nitrogen (99.99 %) was used as carrier gas at a constant flow rate of 0.79 mL min^{-1} and linear velocity 26.00 cm S^{-1}. The injection volume of 2 µL with a split ratio of 1:10 was set in the auto sampler (Shimadzu ADL 20S) and auto injector (AOC 20i).

Two micro litre of each working standard (0.50, 0.10, 0.075, 0.05, 0.025 and 0.01 mg kg^{-1}) was injected in the Gas Chromatograph under set standard GC conditions. Each standard was injected thrice and the Limit of Detection (LOD) of the instrument was calculated for each pesticide, based on the lowest concentration of pesticide that could be identified under standard GC conditions. LOD was estimated from the chromatogram corresponding to the lowest point used in the matrix-matched calibration. The Limit of Detection (LOD) for the pesticides is considered to be the concentration that produced a signal to noise ratio of more than three.

3.1.3 Calibration and Linearity

Five concentration levels (0.05, 0.075, 0.10, 0.25 and 0.50 mg kg^{-1}) of analyte mixture of nine pesticides in two replicates were analyzed to establish the calibration curves. The calibration curve was plotted with concentration of pesticide at X-axis and peak area count at Y-axis. Simple linear regression analysis was performed to calculate the slope and the intercept. The linearity of each analyte was tested using the least square regression method and the coefficient of determination (R^2) was calculated.

3.1.4 Determination of Limit of Quantification (LOQ)

Limit of Quantification (LOQ) of the analytical methodology for the extraction of pesticide residues was also calculated. It is the lowest level meeting the method performance acceptability criteria (mean recoveries for each representative commodity in the range 70 - 120 %, with a RSD < 20 %).

3.1.5 Determination of Recovery and Repeatability

Recovery studies were carried out in order to establish the reliability of the method and to know the efficiency of extraction and clean up steps employed for the present study. The pesticide free spices were homogenized and spiked at three different concentrations such as *viz.*, LOQ level (0.05 mg kg^{-1}), 5 × LOQ (0.25 mg kg^{-1}) and 10 × LOQ (0.50 mg kg^{-1}) using analytical standard solution of insecticides (Table 5). All spiked concentrations were replicated three times and equilibrated and processed by adopting QuEChERS method.

3.1.5.1 Sample Processing of Peppermint Leaves, Coriander Leaves and Ginger

One kilogram each of control samples of peppermint leaves, coriander leaves and ginger (pesticide free samples from organic market) were blended to a fine paste from which a representative sample of 25 g was taken in 200 mL centrifuge bottle in three replicates each. It was then spiked with pesticides (Table 5) at the required fortification levels *i.e.*, LOQ (0.05 mg kg^{-1}), 5 x LOQ (0.25 mg kg^{-1}) and 10 x LOQ (0.5 mg kg^{-1}), adding an appropriate volume of working standard of 10 mg L^{-1}. The spiked sample was then shaken thoroughly to attain proper homogeneity. The tubes were left open for a while just to allow the evaporation of excess solvent. To this mixture, a volume of 50 mL acetonitrile was added and then homogenized in centrifuge at 14000 rpm for one minute to attain homogeneity of the sample. To this mixture, 10 g of sodium chloride was added and centrifuged at 2000-2500 rpm for four minute. From this, 16 mL supernatant was transferred to a 50 mL centrifuge tube containing 6 g sodium sulphate and vortexed for two minutes. After vortexing, 12 mL supernatant was transferred to a 15 mL centrifuge tube containing 1.2 g magnesium sulphate and 0.2 g Primary Secondary Amine (PSA) and vortexed for 30 s and centrifuged at 2500 rpm for three minutes. From this 4.0 mL of the upper layer was transferred to test tubes (30 mL) and solvent was evaporated by using turbovap at 50

^{0}C under a constant flow of nitrogen using a nitrogen generator. The dry residue was reconstituted to one mLusing n-hexane and analyzed in a Gas Chromatograph.

3.1.5.2 Sample Processing of Red Chilli (dry), Cumin Seed and Fennel

Eight gram each of coarsely ground dry red chilli fruits, cumin seed and fennel samples (pesticide free samples from organic market) were taken in 50 mL centrifuge tubes in three replicates each. It was then spiked with pesticides (Table 5) at the required fortification levels *i.e.,* LOQ (0.05 mg kg^{-1}), 5 x LOQ (0.25 mg kg^{-1}) and 10 x LOQ (0.50 mg kg^{-1}), adding an appropriate volume of working standard of 10 mg L^{-1}. This mixture was then shaken, in order to attain a proper homogeneity of pesticides in the samples. The tubes containing fortified samples were left open for a while, just to allow the evaporation of excess solvent. To this, 4.0 g activated magnesium sulphate and 1.0 g sodium chloride were added. Then 10 mL of chilled distilled water (4 ^{0}C) and 15 mL of acetonitrile were added and the samples were shaken for one min in a vortex and centrifuged at 3500 rpm for two minutes. A dispersive solid phase extraction cleanup process was carried out by transferring the supernatant (6.0 ml) to a centrifuge tube (15 ml) containing 1.0 g magnesium sulphate (hydrated), 0.30 g PSA (Primary Secondary Amine) and 0.50 g florisil. These tubes containing the supernatant and the reagents were shaken for few seconds followed by centrifugation at 3500 rpm for two minutes. The cleaned supernatant was evaporated to dryness using turbovap (50 ^{0}C). The dry residue was reconstituted to one mL with a mixture of n-hexane: acetone (7:3, v/v basis) and analyzed in a Gas Chromatograph

3.1.5.3. Estimation

One μL of extracts of each sample was injected into Gas Chromatograph. The extracts were analyzed in a Gas Liquid Chromatograph (Shimadzu GC-2010) equipped with ^{63}Ni Electron Capture Detector (ECD) under working parameters as detailed under section 3.1.2.

3.1.5.4 Residue Quantification and Recovery Calculation

Pesticide residue in substrate (mg kg^{-1}) =

$$\frac{\text{Peak area of sample} \times \text{Concentration of standard injected} \times \text{Volume of sample injected} \times \text{Dilution Factor (DF)}}{\text{Peak area of standard} \times \text{Volume of standard injected}}$$

Dilution Factor (DF) =

$$\frac{\text{Volume of solvent added} \times \text{Final volume of the extract}}{\text{Weight of sample (g)} \times \text{Volume of extract taken for concentration}}$$

Percentage recovery (%) =

$$\frac{\text{Concentration of pesticide residue obtained} \times 100}{\text{Concentration of pesticide residue added}}$$

3.2 STANDARDIZATION OF DIFFERENT HOUSEHOLD PRACTICES ON THE REMOVAL OF PESTICIDE RESIDUES FROM LEAFY SPICES

Test plants were raised with cuttings of peppermint and seedlings of coriander in grow bags filled with 1:2:1 potting mixture (sand: soil: coir pith) and were maintained organically for the study.

The insecticides commonly detected from the market samples of leafy spices *viz.*, dimethoate, chlorpyriphos, quinalphos, lambda cyhalothrin, bifenthrin, ethion, cypermethrin and fenvalerate (GOK, 2015) were sprayed on 30 day old peppermint and coriander leaves using hand sprayer by preparing 25 ppm solution of each insecticide by diluting required amount of each formulation separately in one litre of water (Table 5). The plants were uprooted one day after spraying and roots were cut and removed and 250 g of each sample were subjected to different washing techniques using household products. Each treatment was replicated thrice and untreated control sample was maintained for comparison.

Following washing treatments were evaluated for their efficacy in removing pesticide residues:-

T1- Dipping for five minutes in two per cent suspension of commercial tamarind paste followed by three washings in tap water.

T2- Dipping for five minutes in two per cent solution of common salt followed by three washings in tap water.

T3- Dipping for five minutes in two per cent suspension of turmeric powder followed by three washings in tap water

T4- Dipping for five minutes in two per cent synthetic vinegar followed by three washings in tap water

T5- Dipping in KAU Veggie wash at 10 mL L^{-1} for five minutes followed by three washings in tap water

T6- Dipping for five minutes in tap water followed by three normal washing.

T7- Untreated (control)

Following cooking treatments were evaluated for their efficacy in removing pesticide residues:-

T1- Dipping five minutes in tap water followed by cooking for 10 minutes (closed pan)

T2- Dipping five minutes in tap water followed by cooking for 10 minutes (open pan)

T3- Dipping five minutes in tamarind, followed by cooking (closed pan) for 10 minutes

T4- Dipping five minutes in common salt, followed by cooking (closed pan) for 10 minutes

T5- Dipping five minutes in turmeric, followed by cooking (closed pan) for 10 minutes

T6- Dipping five minutes in vinegar, followed by cooking (closed pan) for 10 minutes

T7- Dipping five minutes in veggie wash 10 mL L^{-1}, followed by cooking (closed pan) for 10 minutes

T8 – Untreated (control)

Samples were then homogenised after chopping into small pieces and the representative sample (25 g) in three replicates was used for residue estimation. The analytical procedure for residue estimation was followed as described under section 3.1.5.1. The residues present in unprocessed and processed samples were estimated and the percentage of removal of residues was calculated.

. The percentage of residue removal was calculated by using the following formula.

Percentage of residue removal =

$$\frac{\text{Amount of residue in unprocessed sample} - \text{Amount. of residue in processed sample} \times 100}{\text{Amt of residues in unprocessed sample}}$$

3.3 EFFECT OF DIFFERENT HOUSEHOLD PRACTICES ON THE REMOVAL OF PESTICIDE RESIDUE FROM RED CHILLI (DRY)

The organic chilli fruits procured from the organic market were brought to the laboratory, washed thoroughly. Then the fruits were sprayed with the commonly detected insecticides in market samples *viz.,* dimethoate, chlorpyriphos, quinalphos, lambda cyhalothrin, bifenthrin, ethion, cypermethrin and fenvalerate by preparing 25 ppm solution of each insecticide by diluting required amount (Table 5) of each formulation separately in one litre of water. Pesticide treated fruits were then sun dried and each lot of dried fruits (250g) were subjected to different decontamination treatments and replicated thrice. Untreated control samples were maintained for comparison.

Following treatments were evaluated for their efficacy in removing pesticide residues:-

T1- Dipping dry chilli fruits in curd and salt followed by sun drying for 1 to 2 h.

T2- Powdering dry chilli fruits as such

T3- Removal of fruit stalk from dry chilli and powdering whole fruits

T4- Powdering of fruits after removal of seeds and stalk

T5- Sauting of dry chilli in frying pan for two minutes

T6- Cooking chilli powder in water for 20 minutes

T7- Drying and powdering chilli fruits after dipping in KAU Veggie wash at 10 mL L^{-1} for five minutes

T8- Drying and powdering chilli fruits after dipping in tap water for five minutes

T11- Untreated (control)

The samples were analyzed separately as per the protocol described in 3.1.5.2 and the levels of pesticide present in the processed and unprocessed commodity was estimated.

The residues present in unprocessed and processed samples were estimated and the percentage of removal of residues was calculated. The percentage removal of residues was calculated by using the formula as mentioned in 3.2.

3.4 EFFECT OF DIFFERENT HOUSEHOLD PRACTICES ON THE REMOVAL OF PESTICIDE RESIDUES FROM CUMIN SEED AND FENNEL

Cumin seed and fennel were procured from the local market and brought to the laboratory. It was washed two times in tap water to remove traces of pesticide on the surface if any. These seeds were sprayed with the commonly detected insecticides in the market samples *viz.,* dimethoate, chlorpyriphos, quinalphos, lambda cyhalothrin, bifenthrin, ethion, cypermethrin and fenvalerate by preparing 25 ppm solution of each insecticide by diluting required amount (Table 5) of each formulation separately in one litre of water. The sprayed seeds were spread uniformly for drying for one day and then subjected to different washing techniques using household products.

Following treatments were evaluated for their efficacy in removing pesticide residues:-

T1 - Dipping for five minutes in two per cent suspension of commercial tamarind paste followed by three washings in tap water

T2 - Dipping for five minutes in two per cent solution of common salt followed by three washings in tap water

T3 - Dipping for five minutes in two per cent suspension of turmeric powder followed by three washings in tap water

T4 - Dipping for five minutes in two per cent synthetic vinegar followed by three washings in tap water

T5 - Dipping in KAU veggie wash at 10 mL L^{-1} for five minutes followed by three washings in tap water

T6 - Dipping for five minutes in two per cent synthetic vinegar followed by three washings in tap water

T8 – Untreated (Control)

3.4.1 Water Sample Analysis

Insecticide treated, cumin seeds were boiled with water and then the seeds and water were analyzed separately to study the persistence of pesticide in the water. Seeds were dried, powdered and analysed separately as per the protocol described in 3.1.5.2. Procedure for the analysis of water sample is described below:-

750 mL water sample was taken in a one litre separating funnel. To this 150g Nacl and 75 mL dichloromethane (DCM) were added and the samples were shaken for five minutes on the mechanical shaker at 250 rpm. The organic layer (DCM) was collected and then the partitioning was repeated with 40 mL DCM and 50mL Hexane. Then the organic layer were combined and concentrated to 5 mL. To this 2 x 20 mL n-Hexane was added, concentrated and made up to one mL and analyzed in a Gas Chromatograph.

Pesticide residue in substrate (mg kg^{-1}) = Concentration from calibration curve

$\times$ Dilution factor

The residues present in unprocessed and processed samples were estimated and the percentage of residue removal was calculated. The percentage removal of residues was calculated by using the formula as mentioned in 3.2.

3.5 EFFECT OF DIFFERENT HOUSEHOLD PRACTICES ON THE REMOVAL OF PESTICIDE RESIDUES FROM GINGER

Organically grown ginger was procured from agronomy department and brought to the laboratory. Ginger was washed properly with water to remove the soil particles and dust adhering to the surface. These were uniformly treated with the commonly detected insecticides *viz.*, dimethoate, chlorpyriphos, quinalphos, lambda cyhalothrin, bifenthrin, ethion, cypermethrin and fenvalerate by preparing 25 ppm solution by diluting required amount (Table 5) of each formulation in 1 litre of water. These insecticides were evenly sprayed over ginger using a hand sprayer (1 L) and allowed to dry at room temperature. The sprayed samples were stored under ambient condition for one day. Then it was subjected to different household techniques to remove pesticide residues. Following treatments were evaluated for their efficacy in removing pesticide residues:-

T1- Dipping for five minutes in two per cent suspension of commercial tamarind paste followed by three washings in tap water

T2- Dipping for five minutes in two per cent solution of common salt followed by three washings in tap water

T3- Dipping for five minutes in two per cent synthetic vinegar followed by three washings in tap water

T4- Dipping in KAU veggie wash at 10 mL L^{-1} for five minutes followed by three washings in tap water.

T5- Dipping in water for five minutes followed by three washings in tap water.

T6- Untreated (control).

Different peeling and processing treatments evaluated were:-

T1-Simple washing without peeling

T2- Peeling and washing

T3- Peeling, washing and cooking for two minutes

T4- Dry ginger (Processing and drying)

The samples were analyzed separately as per the protocol described in 3.1.5.1 and the levels of pesticide present in the processed and unprocessed ginger was estimated.

The residues present in unprocessed and processed samples were estimated and the percentage of residue removal was calculated. The percentage removal of residues was calculated by using the formula as mentioned in 3.2.

3.6 DATA ANALYSIS

Data related to each aspect were statistically analysed. Appropriate transformations were made wherever necessary. Significant results were compared on the basis of critical differences. t test was done for the comparison of open pan and closed pan cooking in peppermint and coriander leaves and percentage retention of residues in cumin seed.

3.7 SENSORY EVALUATION

Sensory evaluation was conducted to examine the acceptability of the best three washing treatments for peppermint leaves, coriander leaves, red chillies (dry) cumin seeds, fennel and ginger with respect to their appearance, colour, flavour, texture, taste and overall acceptability. To evaluate the sensory quality of the best three decontamination treatments from Exp no 3.1, 3.2, 3.3 and 3.4, each treated spice was processed into dishes using different recipes where minimum cooking was involved (Table 7).

Table 7: Recipes selected for each spice

Sl. No	Spices	Recipes
1	Peppermint leaves	Chutney
2	Coriander leaves	Chutney
3	Red chilli (dry)	Pickle
4	Cumin	Cumin water
5	Fennel	Potato finger chips with fennel powder
6	Ginger	Curd with ginger

A sensory panel of ten members (untrained) was selected using standard procedures. Evaluation was done using a score card (Appendix 3) with a scale of one to five. A preference test was also conducted by the members for ranking the three best treatments of each recipe.

In order to obtain meaningful interpretation, the different scores assigned by the ten members in the sensory panel were analysed using Kruskal wallis test to get the mean rank value for all the treatments (Arora and Malhan, 1998).

Results

4. RESULT

The results of the study "Management of pesticide residues in select spices" were statistically proved and presented below under following headings.

4.1 VALIDATION OF MULTI RESIDUE METHODS (MRM) FOR PESTICIDE RESIDUE ANALYSIS IN SPICES

For the analysis of pesticide residues in spices, the development of a multi residue method satisfying the requirement of LOD, LOQ, Linearity, Recovery and Repeatability is essential. The results of the method validation studies for different spices are presented below:-

4.1.1 Determination Limit of Detection (LOD), Calibration Curve and Limit of Quantification

The Limit of Detection (LOD) was estimated from the chromatogram corresponding to the lowest point used in the matrix-matched calibration. The LOD of GC for nine pesticides is 0.01mg kg^{-1}. A calibration curve was prepared by plotting different concentrations (0.05, 0.075, 0.10, 0.25 and 0.50) vs. peak area. Good linearity was found within the range of 0.01mg kg^{-1}(Appendix I). The Limit of Quantification (LOQ) of the analytical method for nine pesticides was calculated as 0.05 mg kg^{-1} and LOQs were obtained, by considering a value, 10 times more than that of background noise.

4.1.2 Determination of Recovery and Repeatability

The percentage recovery of each pesticide was calculated by comparing the peak area of the spiked standards with those of the pure standards. Recovery was determined for all the six spices and the percentage recovery obtained in six spices is presented below.

Table 8. Recovery and repeatability of insecticides in peppermint leaves at different fortification levels

Insecticides	Level of fortification					
	0.05 mgkg^{-1} (LOQ)		0.25 mg kg^{-1}(5 x LOQ)		0.50 mg kg^{-1}(10 x LOQ)	
	Mean recovery (%) ± SD	RSD	Mean recovery (%) ± SD	RSD	Mean recovery (%) ± SD	RSD
Dimethoate	106.91 ± 4.43	4.14	100.51 ± 8.79	8.74	98.22 ± 1.15	1.17
Chlorpyriphos	102.35 ± 2.09	2.04	95.55 ± 5.27	5.51	100.30 ± 2.48	2.47
Quinalphos	98.56 ± 2.22	2.26	102.93 ± 7.51	7.30	101.19 ± 1.16	1.14
Profenophos	101.70 ± 3.24	3.18	98.50 ± 2.79	2.83	95.15 ± 9.40	9.88
Ethion	106.05 ± 5.22	4.93	106.91 ± 2.24	2.10	96.46 ± 3.45	3.58
Lambda cyhalothrin	103.37 ± 8.50	8.23	104.77 ± 3.73	3.56	95.92 ± 4.65	4.84
Bifenthrin	106.07 ± 3.41	3.21	107.00 ± 2.40	2.25	94.47 ± 3.96	4.19
Cypermethrin	100.71 ± 2.71	2.69	106.63 ± 2.32	2.17	96.88 ± 3.21	3.31
Fenvalerate	101.06 ± 1.01	0.99	108.09 ± 0.70	0.65	95.58 ± 3.28	3.44

SD = Standard Deviation, RSD = Relative Standard Deviation, LOQ=Limit of Quantification (LOQ)

4.1.2.1 Peppermint Leaves

The method validated for the estimation of different insecticides in peppermint leaves gave good recovery of the target residues. The percentage recovery was determined at three fortification levels 0.05mg kg^{-1} (LOQ), 0.25 mg kg^{-1} (5 x LOQ) and 0.5mg kg^{-1} (10 x LOQ) (Table 8).

At the fortification level of 0.05 mg kg^{-1} the mean percentage recovery of insecticides in the descending order were dimethoate (106.91 per cent), bifenthrin (106.07 per cent), ethion (106.05 per cent), lambda cyhalothrin (103.37 per cent),chlorpyriphos (102.35 per cent), profenophos (101.70 per cent), fenvalerate (101.06per cent), cypermethrin (100.71 per cent) and quinalphos (98.56 per cent) with a relative standard deviation in the accepted range of 0.99 to 8.23.

At 0.25 mg kg^{-1} level of fortification the mean percentage recovery of insecticides in the descending order were fenvalerate (108.09 per cent), bifenthrin (107.00 per cent), ethion (106.91 per cent), cypermethrin (106.63 per cent), lambda cyhalothrin (104.77 per cent), quinalphos (102.93 per cent), dimethoate (100.51 per cent), chlorpyriphos (95.55 per cent) and profenophos (98.50 per cent) with a relative standard deviation in the range of 0.65 to 8.74.

At 0.50 mg kg^{-1} level of fortification the mean percentage recovery of insecticides was satisfactory and they were in the descending order *viz.*, quinalphos (101.19 per cent), chlorpyriphos (100.3 per cent), dimethoate (98.22 per cent), cypermethrin (96.88 per cent), ethion (96.46 per cent), lambda cyhalothrin (95.92 per cent), fenvalerate (95.58 per cent), profenophos (95.15 per cent) and bifenthrin (94.47 per cent), with a relative standard deviation in the range of 1.14 to 9.88. The recovery results indicate that the method is sufficiently reliable for analysis of insecticide residues in peppermint.

Table 9. Recovery and repeatability of insecticides in coriander leaves at different fortification levels

Insecticides	Level of fortification					
	0.05 mgkg^{-1} (LOQ)		0.25 mg kg^{-1}(5 x LOQ)		0.50 mg kg^{-1}(10 x LOQ)	
	Mean recovery (%) ± SD	RSD	Mean recovery (%) ± SD	RSD	Mean recovery (%) ± SD	RSD
Dimethoate	92.51 ± 3.05	3.29	102.40 ± 13.86	13.54	94.58 ± 8.59	9.08
Chlorpyriphos	89.73 ± 7.31	8.15	85.72 ± 7.59	8.85	89.28 ± 8.17	9.16
Quinalphos	82.93 ± 5.62	6.78	81.37 ± 11.67	14.34	83.91 ± 12.79	15.24
Profenophos	103.0 ± 11.61	11.27	84.79 ± 9.67	11.40	88.69 ± 6.31	7.11
Ethion	104.07 ± 10.82	10.39	87.62 ± 10.68	12.18	88.27 ± 3.70	4.20
Lambda cyhalothrin	93.53 ± 5.37	5.74	86.86 ± 4.08	4.70	93.91 ± 2.57	2.73
Bifenthrin	99.80 ± 5.38	5.39	89.96 ± 3.11	3.45	92.18 ± 4.11	4.46
Cypermethrin	99.40 ± 9.56	9.62	88.59 ± 6.32	7.14	91.14 ± 5.70	6.26
Fenvalerate	89.60 ± 11.86	13.24	96.24 ± 4.18	4.34	89.40 ± 16.26	18.18

SD = Standard Deviation, RSD = Relative Standard Deviation ,LOQ=Limit of Quantification (LOQ)

4.1.2.2 Coriander Leaves

The selected method validated for the estimation of different insecticides in coriander leaves gave good recovery of the target residues. The percentage recovery was determined at three fortification levels 0.05mg kg^{-1} (LOQ), 0.25 mg kg^{-1} (5 x LOQ) and 0.5mg kg^{-1} (10 x LOQ) (Table 9).

At the fortification level of 0.05mg kg^{-1}, the mean percentage recovery of insecticides in the descending order were ethion (104.07 per cent), profenophos (103.00per cent), bifenthrin (99.80 per cent), cypermethrin (99.40 per cent), lambda cyhalothrin (93.53 per cent), dimethoate (92.51 per cent), chlorpyriphos (89.73 per cent) , fenvalerate (89.60 per cent) and quinalphos (82.93 per cent) with a relative standard deviation in the range of 3.29 to 13.24.

At 0.25 mg kg^{-1} level of fortification the mean percentage recovery of insecticides in the descending order were dimethoate (102.40 per cent), fenvalerate (96.24 per cent), bifenthrin (89.96 per cent), cypermethrin (88.59 per cent), ethion (87.62 per cent), lambda cyhalothrin (86.86 per cent), chlorpyriphos (85.72 per cent), quinalphos (81.37 per cent) and profenophos (84.79 per cent) with a relative standard deviation in the range of 3.45 to 14.34.

At 0.50 mg kg^{-1} level of fortification the mean percentage recovery of insecticides in the descending order were, quinalphos (83.91 per cent), chlorpyriphos (89.28 per cent), dimethoate (94.58 per cent), lambda cyhalothrin (93.91 per cent), cypermethrin (91.14 per cent), fenvalerate (89.4 per cent), ethion (88.27 per cent), profenophos (88.69 per cent) and bifenthrin (92.18 per cent) with a relative standard deviation in the range of 2.73 to 18.18. The recovery results indicated that the method is sufficiently reliable for pesticide analysis in coriander leaves.

Table 10. Recovery and repeatability of insecticides in red chilli (dry) at different fortification levels

Insecticides	Level of fortification					
	0.05 $mgkg^{-1}$ (LOQ)		0.25 mg kg^{-1}(5 x LOQ)		0.50 mg kg^{-1}(10 x LOQ)	
	Mean recovery (%) ± SD	RSD	Mean recovery (%) ± SD	RSD	Mean recovery (%) ± SD	RSD
Dimethoate	98.56 ± 3.62	3.67	98.62 ± 2.94	2.98	111.93 ± 1.92	1.72
Chlorpyriphos	94.84 ± 2.58	2.72	98.84 ± 2.92	2.96	92.67 ± 2.48	2.68
Quinalphos	97.70 ± 4.35	4.45	101.62 ± 3.15	3.10	97.28 ± 1.66	1.71
Profenophos	103.15 ± 9.52	9.23	104.00 ± 4.17	4.01	89.72 ± 6.83	7.61
Ethion	99.69 ± 6.88	6.90	103.62 ± 1.54	1.49	83.53 ± 6.73	8.06
Lambda cyhalothrin	96.28 ± 7.23	7.51	100.19 ± 3.60	3.59	85.16 ± 7.61	8.93
Bifenthrin	96.54 ± 8.06	8.35	100.25 ± 10.16	10.13	117.33 ± 5.03	4.29
Cypermethrin	87.50 ± 9.12	10.42	100.65 ± 5.28	5.25	104.87 ± 2.61	2.49
Fenvalerate	93.67 ± 4.55	4.85	99.71 ± 6.64	6.66	80.33 ± 3.63	4.52

SD = Standard Deviation, RSD = Relative Standard Deviation ,LOQ=Limit of Quantification (LOQ)

4.1.2.3 Red Chilli

The selected method validated for the estimation of different insecticides in red chilli gave good recovery of the target residues. The percentage recovery was determined at three fortification levels 0.05mg kg^{-1} (LOQ), 0.25 mg kg^{-1} (5 x LOQ) and 0.5mg kg^{-1} (10 x LOQ) (Table 10).

At the fortification level of 0.05mg kg^{-1}, the mean percentage recovery of insecticide in the descending order were profenophos (103.15 per cent), ethion (99.69 per cent), quinalphos (97.70 per cent), dimethoate (98.56 per cent), bifenthrin (96.54per cent), Lambda cyhalothrin (96.28 per cent), chlorpyriphos (94.84 per cent), fenvalerate (93.67 per cent) and cypermethrin (87.50 per cent) with a relative standard deviation in the range of 2.72 to 10.42.

At 0.25 mg kg^{-1} level of fortification the mean percentage recovery of insecticides in the descending order were profenophos (104.00 per cent), ethion (103.62 per cent), quinalphos (101.62 per cent), cypermethrin (100.65 per cent), bifenthrin (100.25 per cent), lambda cyhalothrin (100.19 per cent), fenvalerate (99.71 per cent), chlorpyriphos (98.84 per cent) and dimethoate (98.62 per cent) with a relative standard deviation in the range of 1.49 to 10.13.

At 0.50 mg kg^{-1} level of fortification the mean percentage recovery of insecticides in the descending order were, bifenthrin (117.33 per cent), dimethoate (111.93 per cent), cypermethrin (104.87 per cent), quinalphos (97.28 per cent), chlorpyriphos (92.67 per cent), profenophos (89.72 per cent), lambda cyhalothrin (85.16 per cent), ethion (83.53 per cent) and fenvalerate (80.33 per cent) with a relative standard deviation in the range of 1.71 to 8.93. The recovery results indicated that the method is sufficiently reliable for pesticide analysis in coriander leaves.

Table 11. Recovery and repeatability of insecticides in cumin seed at different fortification levels

Insecticides	Level of fortification					
	0.05 $mgkg^{-1}$ (LOQ)		0.25 mg kg^{-1}(5 x LOQ)		0.50 mg kg^{-1}(10 x LOQ)	
	Mean recovery (%) ± SD	RSD	Mean recovery (%) ± SD	RSD	Mean recovery (%) ± SD	RSD
Dimethoate	100.76 ± 4.21	4.18	74.75 ± 2.70	3.61	95.78 ± 4.66	4.86
Chlorpyriphos	98.71 ± 2.44	2.47	97.69 ± 2.47	2.53	92.34 ± 10.88	11.78
Quinalphos	94.66 ± 10.83	11.44	89.61 ± 17.09	19.07	102.32 ± 9.18	8.97
Profenophos	97.53 ± 7.04	7.21	86.84 ± 6.62	7.62	97.81 ± 1.58	1.62
Ethion	97.03 ± 3.12	3.22	100.35 ± 5.75	5.73	92.36 ± 3.23	3.49
Lambda cyhalothrin	101.47 ± 1.87	1.84	99.55 ± 10.89	10.94	86.89 ± 12.03	13.84
Bifenthrin	99.62 ± 2.43	2.44	91.56 ± 10.13	11.07	90.75 ± 8.06	8.89
Cypermethrin	100.33 ± 2.67	2.66	126.72 ± 7.70	6.08	95.44 ± 2.68	2.81
Fenvalerate	97.45 ± 2.15	2.20	98.37 ± 32.81	20.00	94.97 ± 2.93	3.08

SD = Standard Deviation, RSD = Relative Standard Deviation, LOQ=Limit of Quantification (LOQ)

4.1.2.4 Cumin Seed

The selected method validated for the estimation of different insecticides in cumin gave good recovery of the target residues. The percentage recovery was determined at three fortification levels 0.05mg kg^{-1} (LOQ), 0.25 mg kg^{-1} (5 x LOQ) and 0.5mg kg^{-1} (10 x LOQ) (Table 11).

At the fortification level of 0.05mg kg^{-1}, the mean percentage recovery of insecticides in the descending order were lambda cyhalothrin (101.47 per cent), dimethoate (100.76 per cent), cypermethrin (100.33 per cent), bifenthrin (99.62 per cent), chlorpyriphos (98.71 per cent), profenophos (97.53per cent), fenvalerate (97.45 per cent), ethion (97.03 per cent) and quinalphos (94.66 per cent) with a relative standard deviation in the range of 1.04 to 11.4.

At 0.25 mg kg^{-1} level of fortification the mean percentage recovery of insecticides in the descending order were cypermethrin (110.72 per cent), ethion (100.35 per cent), Lambda cyhalothrin (99.55 per cent), fenvalerate (98.37 per cent), chlorpyriphos (97.69 per cent), bifenthrin (91.56 per cent), quinalphos (89.61 per cent), profenophos (86.84 per cent) and dimethoate (74.75 per cent) with a relative standard deviation in the range of 2.53 to 19.00.

At 0.50 mg kg^{-1} level of fortification, the mean percentage recovery of insecticides in the descending order were quinalphos (102.32 per cent), profenophos (97.81 per cent), dimethoate (95.78 per cent), cypermethrin (95.44 per cent), fenvalerate (94.97 per cent), chlorpyriphos (92.34 per cent), ethion (92.36 per cent) bifenthrin (90.75 per cent), and lambda cyhalothrin (86.89 per cent) with a relative standard deviation in the range of 1.62 to13.84. The recovery results indicate that the method is sufficiently reliable for pesticide analysis in coriander leaves.

Table 12. Recovery and repeatability of insecticides in fennel at different fortification levels

Insecticides	Level of fortification					
	0.05 mgkg^{-1} (LOQ)		0.25 mg kg^{-1}(5 x LOQ)		0.50 mg kg^{-1}(10 x LOQ)	
	Mean recovery (%) ± SD	RSD	Mean recovery (%) ± SD	RSD	Mean recovery (%) ± SD	RSD
Dimethoate	102.80 ± 10.61	10.32	105.19 ± 8.33	7.92	95.73 ± 4.65	4.86
Chlorpyriphos	118.00 ± 14.00	11.86	79.24 ± 2.39	3.02	94.89 ± 3.36	3.54
Quinalphos	117.33 ± 22.03	18.78	103.98 ± 7.19	6.91	96.49 ± 3.87	4.02
Profenophos	114.67 ± 9.45	8.24	98.71 ± 21.47	19.75	97.26 ± 0.43	0.44
Ethion	109.43 ± 18.09	16.53	99.49 ± 1.50	1.51	98.47 ± 1.48	1.50
Lambda cyhalothrin	104.69 ± 4.60	4.40	99.91 ± 2.35	2.35	96.70 ± 3.96	4.09
Bifenthrin	99.46 ± 0.12	0.12	100.61 ± 2.13	2.12	90.58 ± 7.88	8.70
Cypermethrin	98.16 ± 14.29	14.56	94.94 ± 14.95	15.75	96.20 ± 4.95	5.14
Fenvalerate	94.48 ± 3.91	4.14	86.22 ± 13.64	15.82	96.51 ± 4.34	4.50

SD = Standard Deviation, RSD = Relative Standard Deviation ,LOQ=Limit of Quantification (LOQ)

4.1.2.5 Fennel

The selected method validated for the estimation of different insecticides in fennel gave good recovery of the target residues. The percentage recovery was determined at three fortification levels 0.05mg kg^{-1} (LOQ), 0.25 mg kg^{-1} (5 x LOQ) and 0.5mg kg^{-1} (10 x LOQ) (Table 12)

At the fortification level of 0.05mg kg^{-1}, the mean percentage recovery of insecticides in the descending order were chlorpyriphos (118.00 per cent), quinalphos (117.33 per cent), profenophos (114.67 per cent), ethion (109.43 per cent), Lambda cyhalothrin (104.69 per cent), dimethoate (102.80 per cent), bifenthrin (99.46 per cent), cypermethrin (98.16 per cent) and fenvalerate (94.48 per cent) with a relative standard deviation in the range of 0.12 to 18.78.

At 0.25 mg kg^{-1} level of fortification, the mean percentage recovery of insecticides in the descending order were dimethoate (105.19 per cent), quinalphos (103.98 per cent), bifenthrin (100.61 per cent), lambda cyhalothrin (99.91 per cent), ethion (99.49 per cent), profenophos (98.71 per cent), cypermethrin (94.94 per cent), fenvalerate (86.22 per cent) and chlorpyriphos (79.24 per cent) with a relative standard deviation in the range of 1.51 to 18.75.

At 0.50 mg kg^{-1} level of fortification the mean percentage recovery of insecticides in the descending order were ethion (98.47 per cent), profenophos (97.26 per cent), lambda cyhalothrin (96.7 per cent), fenvalerate (96.51 per cent), quinalphos (96.49 per cent), cypermethrin (96.2 per cent), dimethoate (95.73 per cent), chlorpyriphos (94.89 per cent) and bifenthrin (90.58 per cent) with a relative standard deviation in the range of 0.49 to 8.70. The recovery results indicated that the method is sufficiently reliable for pesticide analysis in coriander leaves.

Table 13. Recovery and repeatability of insecticides in ginger at different fortification levels

Insecticides	Level of fortification					
	0.05 mgkg^{-1} (LOQ)		0.25 mg kg^{-1}(5 x LOQ)		0.50 mg kg^{-1}(10 x LOQ)	
	Mean recovery (%) ± SD	RSD	Mean recovery (%) ± SD	RSD	Mean recovery (%) ± SD	RSD
Dimethoate	101.24 ± 2.25	2.22	99.25 ± 17.32	17.45	97.90 ± 0.74	0.76
Chlorpyriphos	100.77±1.34	1.33	85.33±3.45	4.04	95.61±9.96	10.41
Quinalphos	101.62±0.60	0.59	90.40±11.78	13.03	98.81±5.27	5.33
Profenophos	99.99±1.80	1.80	101.07±1.85	1.83	97.60±5.16	5.29
Ethion	100.87±2.22	2.20	104.80±7.99	7.62	95.73±4.65	4.86
Lambda cyhalothrin	94.44±5.53	5.86	103.63±8.56	8.26	96.45±3.96	4.11
Bifenthrin	97.27±5.75	5.91	108.80±4.80	4.41	94.89±3.36	3.54
Cypermethrin	97.37±2.81	2.88	111.09±10.34	9.31	96.49±3.87	4.02
Fenvalerate	99.91±0.36	0.36	100.56±13.67	13.60	97.26±0.43	0.44

SD = Standard Deviation, RSD = Relative Standard Deviation, LOQ=Limit of Quantification (LOQ)

4.1.2.6 Ginger

The selected method validated for the estimation of different insecticides in ginger gave good recovery of the target residues. The percentage recovery was determined at three fortification levels 0.05mg kg^{-1} (LOQ), 0.25 mg kg^{-1} (5 x LOQ) and 0.5mg kg^{-1} (10 x LOQ) (Table 13).

At the fortification level of 0.05mg kg^{-1}, the mean percentage recovery of insecticides in the descending order were dimethoate (101.24 per cent), quinalphos (101.62 per cent), ethion (100.87 per cent), chlorpyriphos (100.77 per cent), profenophos (99.99 per cent), fenvalerate (99.91 per cent), cypermethrin (97.37 per cent), bifenthrin (97.27 per cent) and Lambda cyhalothrin (94.44 per cent) with a relative standard deviation in the range of 0.59 to 5.91.

At 0.25 mg kg^{-1} level of fortification, the mean percentage recovery of insecticides in the descending order were cypermethrin (111.09 per cent), bifenthrin (108.80 per cent), ethion (104.80 per cent), lambda cyhalothrin (103.63 per cent), profenophos (101.0 per cent), fenvalerate (100.56 per cent), dimethoate (99.25 per cent), quinalphos (90.40 per cent) and chlorpyriphos (85.33 per cent) with a relative standard deviation in the range of 1.83 to 19.65.

At 0.50 mg kg^{-1} level of fortification, the mean percentage recovery of insecticides in the descending order were quinalphos (98.81 per cent), dimethoate (97.90 per cent), profenophos (97.60 per cent), fenvalerate (97.26 per cent), lambda cyhalothrin (96.45 per cent), , cypermethrin (96.49 per cent), ethion (95.73 per cent), chlorpyriphos (95.61 per cent) and bifenthrin (94.89 per cent) with a relative standard deviation in the range of 0.76 to 10.41. The recovery results indicated that the method is sufficiently reliable for pesticide analysis in coriander leaves.

4.2 STANDARDIZATION OF WASHING WITH SOLUTIONS OF HOUSEHOLD PRODUCTS TO REMOVE PESTICIDE RESIDUES FROM LEAFY SPICES

4.2.1 Peppermint Leaves

4.2.1.1 Effect of Different Washing Solutions on the removal of Organophosphate Insecticide Residues

The results of 4.2.1.1 are presented in Table14

4.2.1.1 .1 Dimethoate

The treatments, *viz.,* dipping in two per cent turmeric solution, two per cent synthetic vinegar solution and KAU Veggie wash (10 mL L^{-1}) for five minutes showed significantly higher percentage reduction of dimethoate residues, to the tune of 29.19, 27.74 and 34.80 percent respectively. However, percentage removal of residues observed in treatments like dipping in solutions of two per cent common salt (23.72 per cent), two per cent tamarind (21.43 per cent) and tap water (23.12 per cent) were statistically on par.

4.2.1.1 .2 Quinalphos

All the decontamination treatments differed in their efficacy in removing quinalphos residues detected in peppermint leaves one day after spraying. Dipping the leaves in two per cent turmeric solution, two per cent synthetic vinegar solution and KAU Veggie wash (10 mL L^{-1}) for five minutes followed by three normal washing in tap water were significantly superior in the removal of residues, to the tune of 54.80, 52.25 and 56.31 per cent respectively. However, when the leaves were dipped in two per cent common salt solution and two per cent tamarind solution followed by three washing in tap water, reduced the residues up to 45.82 and 45.50 per cent respectively. Dipping in tap water alone for five minutes reduced only 41.01 per cent of residues.

Table 14. Extent of removal of residues of organophosphate insecticides from peppermint leaves after dipping in different solutions

Treatments	Mean per cent removal of insecticides (%)** ± SD				
	Dimethoate	Quinalphos	Chlorpyriphos	Profenophos	Ethion
T1-2% tamarind paste*	21.43 ± 2.81(5.00)[b]	45.50 ± 2.76(6.74)[bc]	46.21 ± 2.37(6.79)[b]	31.80 ± 6.36(5.62)[cd]	47.74 ±6.01(6.90)[b]
T2-2% common salt*	23.72 ± 6.62(4.84)[b]	45.82 ± 4.88(6.76)[bc]	40.52 ± 6.02(6.35)[b]	40.73 ± 1.73(6.38)[bc]	47.53 ±3.46(6.89)[b]
T3- 2% turmeric powder*	29.19 ± 6.00(5.38)[a]	54.80 ± 4.51(7.39)[ab]	48.84 ± 5.45(6.98)[a]	54.03 ± 8.60(7.34)[a]	57.05 ±3.42(7.55)[a]
T4- 2% synthetic vinegar *	27.74 ± 1.01(5.27)[ab]	52.25 ± 5.91(7.22)[ab]	51.04 ± 4.17(7.10)[a]	51.00 ± 6.13(7.14)[ab]	58.42 ±1.58(7.64)[a]
T5- KAU Veggie wash 10mlL^{-1} *	34.80 ± 1.25(5.90)[ab]	56.31 ± 5.95(7.49)[a]	50.76 ± 8.73(7.14)[a]	54.49 ± 7.76(7.38)[a]	57.30 ±5.46(7.56)[a]
T6- tap water*	23.12 ± 4.20(4.79)[b]	41.01 ± 7.69(6.38)[c]	38.76 ± 6.79(6.20)[c]	27.05 ± 10.81(5.13)[d]	46.27 ±2.76(6.80)[b]
CD(0.05)	(0.749)	(0.750)	(0.302)	(0.832)	(0.225)

Values shown in parentheses are $\sqrt{x+1}$ transformed values. Values are significantly different from each other by LSD at 5 %
*Subjected to dipping in treatment solutions for 5 minutes followed by three normal washings
** Mean of three replications

4.2.1.1 .3 Chlorpyriphos

Peppermint leaves dipped in two per cent synthetic vinegar solution, KAU Veggie wash 10 mL L^{-1} and two per cent turmeric solution for five minutes followed by three normal washings could remove 51.04, 50.76 and 48.84 per cent of chlorpyriphos residues respectively. Dipping in two per cent tamarind solution and two per cent common salt solution for five minutes followed by three washing recorded a removal of 46.21 and 40.52 per cent respectively. The least removal of residues (38.76 per cent) was observed in simple washing with tap water.

4.2.1.1 .4 Profenophos

The treatments *viz.,* dipping of peppermint leaves in two per cent turmeric solution and KAU Veggie wash (10 mL L^{-1}) for five minutes followed by three normal washing facilitated the removal of 54.03 and 54.49 percent residues of profenophos respectively. These treatments were found to be the best for reducing profenophos residues and it was closely followed by dipping in two per cent synthetic vinegar solution (51.00 per cent), two per cent common salt solution (40.73 per cent) and two per cent tamarind solution (31.80 per cent). Based on the percentage removal, it was statistically proved that there is a significant reduction in profenophos residue for all the decontaminating treatments when compared with dipping in tap water (27.05 per cent).

4.2.1.1 .5 Ethion

The residues of ethion were removed to varying extent by different decontamination treatments. The superior treatments were dipping the leaves for five minutes in two per cent synthetic vinegar solution (58.42 per cent), KAU veggie wash 10 mL L^{-1} (57.30per cent) and two per cent turmeric solution (57.05per cent). All these treatments were on par in their effect. Dipping in two per cent tamarind solution, two per cent common salt solution and tap water for five minutes followed by three normal washing with tap water removed 47.74, 47.53 and 46.27 per cent of residues respectively.

4.2.1.2 Effect of Different Washing Solutions on the removal of Synthetic Pyrethroid Insecticides Residues

The results of 4.2.1.2 are presented in Table15

4.2.1.2.1 Bifenthrin

Dipping in two per cent synthetic vinegar solution and KAU Veggie wash (10 mL L^{-1}) for five minutes resulted in more than 40 per cent removal of bifenthrin residues one day after spraying and these treatments were significantly superior over all other treatments. There was no significant difference in percentage removal of bifenthrin residues when dipped in two per cent turmeric solution (29.34 per cent) and two per cent tamarind solution (28.06 per cent). A significant reduction in residue was observed for all decontamination solutions except two per cent common salt solution (21.45 per cent) when compared with dipping for five minutes in tap water (20.87 per cent).

4.2.1.2.2 Lambda cyhalothrin

The decontamination processes effectively removed residues of lambda cyhalothrin from 29.69 to 48.99 percent. Highest removal was observed in dipping the leaves in two per cent synthetic vinegar solution (48.99 per cent), KAU Veggie wash 10 mL L^{-1} (43.42 per cent), two per cent turmeric solution (42.17 per cent) and two per cent common salt solution (42.06 per cent) for five minutes followed by three washings with tap water. These treatments were proved to be statistically on par. The next best treatment was dipping the leaves for five minutes in two per cent tamarind solution (33.08 per cent). The treatment which gave the least removal was dipping in tap water (29.69 per cent).

4.2.1.2.3 Cypermethrin

Among all the decontamination treatments, the superior treatments for removing chlorpyriphos residues were dipping the leaves for five minutes in two

Table 15: Extent of removal of residues of synthetic pyrethroid insecticides from peppermint leaves after dipping in different solutions

Treatments	Mean per cent removal of insecticides (%)** ± SD			
	Bifenthrin	Lambda-cyhalothrin	Cypermethrin	Fenvalerate
T1-2% tamarind paste*	28.06 ±1.11(5.24)^{bc}	33.08 ± 6.01(5.73)^{bc}	30.33 ± 2.50(5.50)^{c}	31.30 ± 6.51(5.57)^{cd}
T2-2% common salt*	21.45 ±6.72(4.59)^{c}	42.06 ± 4.84(6.48)^{ab}	32.09 ± 5.00(5.65)^{bc}	26.75 ± 5.00(5.16)^{cd}
T3- 2% turmeric powder*	29.34 ±9.63(5.36)^{abc}	42.17 ± 4.32(6.49)^{a}	40.17 ± 0.27(6.33)^{a}	34.4 ± 3.01(5.86)^{bc}
T4- 2% synthetic vinegar *	43.24 ± 4.61(6.50)^{ab}	48.99 ± 9.12(6.98)^{a}	39.05 ± 3.52(6.31)^{a}	44.14 ± 9.92(6.61)^{ab}
T5- KAU Veggie wash $10mlL^{-1}$ *	46.91 ± 5.65(6.84)^{a}	43.42 ± 2.51(6.59)^{a}	38.10 ± 3.30(6.16)^{ab}	49.23 ± 3.22(7.01)^{a}
T6- tap water*	20.87 ± 5.84(4.54)^{c}	29.69 ± 2.72(5.45)^{c}	28.20 ± 3.01(5.30)^{c}	22.53 ± 5.31(4.72)^{d}
CD(0.05)	(1.512)	(0.750)	(0.527)	(0.920)

Values shown in parentheses are $\sqrt{x+1}$ transformed values. Values are significantly different from each other by LSD at 5 %
*Subjected to dipping in treatment solutions for 5 minutes followed by three normal washings
** Mean of three replications

per cent turmeric solution (40.17 per cent), two per cent synthetic vinegar solution (39.05 per cent) and KAU Veggie wash 10 mL L^{-1} (38.10 per cent) followed by three washings with tap water. These treatments were statistically on par. The next best treatments were two per cent common salt solution (32.09 per cent), two per cent tamarind solution (30.33 per cent) and tap water (28.2 per cent). It was proved that these treatments were statistically on par.

4.2.1.2.4 Fenvalerate

The percentage removal of fenvalerate residues from peppermint leaves when subjected to different decontamination solutions at one day after spraying showed that dipping in KAU Veggie wash (10 mL L^{-1}) and two per cent synthetic vinegar solution for five minutes followed by three washings with tap water followed by three washings with tap water were found to be most effective in removing 49.23 and 44.14 per cent of residues respectively. It was proved that these treatments were statistically on par. The next promising treatment was dipping in two per cent turmeric solution (34.40 per cent) followed by two per cent tamarind solution (31.30 per cent). However, the percentage residue removal through dipping in two per cent common salt solution (26.75 per cent) and tap water (22.53 per cent) were less compared to other treatments.

4.2.1.3 Effect of Different Cooking Treatments on the Removal of Organophosphate Insecticides Residues

The results of 4.2.1.3 are presented in Table16

4.2.1.3.1 Dimethoate

The percentage removal of dimethoate residues from peppermint leaves when cooked in closed pan for ten minutes after dipping in different solutions for five minutes at one day after spraying showed that KAU Veggie wash (10 mL L^{-1}) plus cooking was found to be most effective in removing 64.65 per cent of dimethoate residues. The next promising treatments were dipping in two per cent

Table 16: Extent of removal of residues of organophosphate insecticides from peppermint leaves (different dipping plus cooking)

Treatments	Mean per cent removal of insecticides (%)** ± SD				
	Dimethoate	Quinalphos	Chlorpyriphos	Profenophos	Ethion
T1- 2% tamarind* + cooking (closed pan)	36.5 ± 6.82(6.03)^{bc}	54.98 ± 3.53(7.31)^{c}	49.93 ± 4.69(7.06)^{c}	42.08 ± 3.05(6.48)^{bc}	54.41 ±1.92(7.37)^{c}
T2- 2% common salt* + cooking (closed pan)	42.11 ± 6.33(6.48)^{b}	55.62 ± 2.17(7.45)^{b}	49.19 ± 3.04(7.01)^{c}	40.40 ± 3.05(6.21)^{c}	56.56±2.46(7.52)^{c}
T3- 2% turmeric* + cooking (closed pan)	41.85 ± 5.10(6.46)^{b}	59.51 ± 4.33(7.71)^{ab}	57.43 ± 5.63(7.57)^{ab}	52.59 ± 6.49(7.24)^{a}	64.42 ±1.97(8.02)^{a}
T4- 2% vinegar* + cooking (closed pan)	43.71 ± 4.41(6.61)^{b}	63.94 ± 3.32(7.99)^{a}	54.92 ± 3.48(7.40)^{a}	49.53 ± 3.77(7.03)^{ab}	60.82±2.93(7.79)^{ab}
T5- KAU Veggie wash at 10 ml L^{-1} *+ cooking (closed pan)	54.65 ± 3.50(8.04)^{a}	66.89 ± 2.00(8.17)^{a}	59.66 ± 2.62(7.72)^{abc}	56.76 ± 3.09(7.53)^{a}	64.10 ±5.70(8.00)^{a}
T6- tap water* + cooking (closed pan)	32.11 ± 4.81(5.66)^{c}	53.50 ± 3.73(7.41)^{d}	45.93 ± 5.69(7.09)^{bc}	38.61 ± 4.92(6.58)^{c}	56.71 ±0.72(6.91)^{c}
CD(0.05)	(0.740)	(0.364)	(0.501)	(0.530)	(0.282)

Values shown in parentheses are $\sqrt{x+1}$ transformed values. Values are significantly different from each other by LSD at 5 %
*Subjected to dipping in treatment solutions for 5 minutes followed by three normal washings
** Mean of three replications

synthetic vinegar solution plus cooking (43.71 per cent), two per cent turmeric solution plus cooking (41.85 per cent) and two per cent common salt solution plus cooking (42.11 per cent) However, the percentage residue removal through dipping in two per cent tamarind solution (36.5 per cent) and tap water (32.11 per cent) were significantly lower when compared with other treatments.

4.2.1.3.2 Quinalphos

Cooking peppermint leaves in closed pan for 10 minutes after dipping in KAU Veggie wash (10 mL L^{-1}) and two per cent synthetic vinegar solution for five minutes showed comparatively higher reduction of 66.89 percent and 63.94 per cent of quinalphos residues respectively. All other treatments such as dipping in two per cent turmeric solution plus cooking (closed pan), two per cent common salt solution plus cooking (closed pan), two per cent tamarind solution plus cooking (closed pan) and tap water plus cooking were proved to be statistically on par and which facilitated a removal of 59.51, 55.62, 54.98 and 53.50 per cent of quinalphos residues respectively.

4.2.1.3.3 Chlorpyriphos

Among all cooking treatments, the best treatment for removing chlorpyriphos residues was dipping the leaves for five minutes in two per cent synthetic vinegar solution followed by cooking in closed pan for 10 minutes. The next best cooking treatment was two per cent turmeric solution plus cooking (closed pan). The losses incurred due to other cooking treatments were 57.43 (2 per cent turmeric plus cooking), 49.19 (2 per cent common salt solution plus cooking) and 49.93 per cent (two per cent tamarind solution plus cooking). Overall, a significant reduction in chlorpyriphos residues was observed for cooking after dipping in different decontaminating solutions when compared with washing in tap water plus cooking (45.93 per cent).

4.2.1.3.4 Profenophos

Cooking of peppermint leaves for 10 minutes in closed pan after dipping in two per cent synthetic vinegar solution for five minutes facilitated the removal of 49.53 per cent residues. This cooking after vinegar treatment was statistically proved to be the best treatments for reducing profenophos residues and it was closely followed by dipping in KAU veggie wash 10 mL L^{-1} plus cooking (56.76 per cent).). The removal of insecticide residues due to other cooking treatments were 42.59 (2 per cent turmeric plus cooking), 42.08 (2 per cent tamarind solution plus cooking) and 40.40 per cent (2 per cent common salt solution plus cooking). Based on the percentage removal, it was statistically proved that there was a significant reduction in profenophos residue for all the decontaminating solutions when compared with dipping in tap water plus cooking (38.61 per cent).

4.2.1.3.5 Ethion

Among all cooking treatments, the superior treatment for removing ethion was dipping the peppermint leaves in KAU veggie wash 10 mL L^{-1} followed by cooking for 10 minutes (64.10 per cent) and dipping in two per cent turmeric solution plus cooking (64.42 per cent). The next promising treatment was dipping in two per cent vinegar solution plus cooking (60.82 per cent) for 10 minutes in closed pan. There was no significant difference in percentage removal of ethion residues in peppermint leaves when cooked for 10 minutes in closed pan after dipping in two per cent salt solution (56.56 per cent), tap water (56.71 per cent) and in two per cent tamarind solution (54.41 per cent).

4.2.1.4 *Effect of Different Cooking Treatments on the removal of Synthetic Pyrethroid Insecticide Residues*

The results of 4.2.1.4 are presented in Table17

4.2.1.4.1 Bifenthrin

The percentage removal of bifenthrin residues in peppermint leaves when cooked for 10 minutes in closed pan after dipping in two per cent synthetic vinegar solution and two per cent turmeric plus cooking were 56.92 and 69.23 percent respectively and both the treatments were significantly superior to all the other treatments. Dipping in other decontamination solutions followed by cooking resulted in less than 50per cent removal of residues *i.e.,* two per cent common salt plus cooking (44.62 per cent), KAU Veggie wash 10 mL L^{-1} (42.00 per cent), two per cent tamarind plus cooking (33.85per cent) and two per cent tap water plus cooking (32.86 per cent).

4.2.1.4 Lambda cyhalothrin

In the case of Lambda cyhalothrin, per cent removal in all the treatments showed statistical difference when compared with unprocessed samples and the mean per cent values ranged from 36.49 to 58.67. Among all treatments, highest removal was observed in dipping the leaves in two per cent turmeric solution plus cooking (58.50 per cent), two per cent vinegar solution plus cooking (58.56 per cent) and KAU Veggie wash(10 mL L^{-1}) plus cooking (58.67 per cent) for 10 minutes in closed pan. The next best promising treatments were dipping in two per cent tamarind solution plus cooking (42.54 per cent), and two per cent common salt solution plus cooking (45.08 per cent). The treatment which gave least removal was dipping in tap water plus cooking (36.49per cent).

4.2.1.4.3 Cypermethrin

The percentage removal of cypermethrin residues from peppermint leaves when subjected to different cooking treatments showed that dipping in two per cent synthetic vinegar solution plus cooking and KAU Veggie wash (10 mL L^{-1}) plus cooking were found to be most effective in removing 46.97 and 41.57 per cent of residues respectively. It was proved that these treatments were statistically on par. The next promising treatment was dipping in two per cent tamarind

Table17: Extent of removal of residues of synthetic pyrethroid insecticides from peppermint leaves (different dipping plus cooking)

Treatments	Mean per cent removal of insecticides (%)** ± SD			
	Bifenthrin	Lambda-cyhalothrin	Cypermethrin	Fenvalerate
T1- 2% tamarind* + cooking (closed pan)	33.85 ± 6.71(5.38)^{d}	42.54 ± 2.65(6.52)^{b}	41.3 ± 4.61(6.42)^{ab}	40.8 ± 2.40(6.39)^{bc}
T2- 2% common salt* + cooking (closed pan)	44.62 ± 2.17(6.76)^{c}	45.08 ± 2.88(6.71)^{b}	29.8 ± 2.65(5.45)^{bc}	36.70 ± 7.31(6.04)^{bc}
T3- 2% turmeric* + cooking (closed pan)	69.23 ± 3.26(7.85)^{a}	58.50 ± 3.10(7.64)^{a}	39.3 ± 9.38(6.23)^{abc}	43.62 ± 4.96(6.60)^{ab}
T4- 2% vinegar* + cooking (closed pan)	56.92 ±0.81(7.65)^{ab}	58.56 ± 1.25(7.65)^{a}	46.97 ± 7.01(6.84)^{a}	45.96 ± 3.54(6.78)^{ab}
T5- KAU Veggie wash at 10 ml L^{-1}*+ cooking (closed pan)	42.00 ± 4.19(7.12)^{bc}	58.67 ± 1.15(7.62)^{a}	41.57 ± 3.40(6.44)^{a}	48.61 ± 7.05(6.96)^{a}
T6- tap water* + cooking (closed pan)	32.86 ± 7.23(5.80)^{d}	36.49 ± 1.70(6.04)^{c}	20.14 ± 9.12(5.44)^{c}	33.16 ± 5.55(5.74)^{c}
CD(0.05)	(0.634)	(0.282)	(0.971)	(0.779)

Values shown in parentheses are $\sqrt{x+1}$ transformed values. Values are significantly different from each other by LSD at 5 %
*Subjected to dipping in treatment solutions for 5 minutes followed by three normal washings
** Mean of three replications

solution plus cooking (41.30 per cent) followed by two per cent turmeric solution plus cooking (39.32 per cent). However, the percentage residue removal through dipping in two per cent common salt solution plus cooking (29.80per cent) and tap water plus cooking (20.14per cent) were less compared to other treatments.

4.2.1.4.4 Fenvalerate

The percentage removal of fenvalerate residues from peppermint leaves when subjected to different cooking treatments showed that dipping in KAU Veggie wash (10 mL L^{-1}) plus cooking (48.61 per cent), two per cent vinegar solution plus cooking (45.96 per cent) and two per cent turmeric plus cooking (43.62 per cent) were found to be most effective in removing residues of fenvalerate. These treatments were statistically on par. The next best treatments were dipping in two per cent tamarind solution plus cooking (40.80 per cent) and two per cent common salt solution plus cooking (36.70 per cent).

4.2.1.5 Effect of Open Pan and Close Pan Cooking Treatments on the removal of Insecticide Residues

Removal of residues from peppermint leaves when cooked in closed pan and open pan did not differ significantly for all the insecticides tested (Table 18).

4.2.2 Coriander Leaves

The effect of different decontamination treatments in removing the residues of organophosphate and synthetic pyrethroid insecticides from coriander leaves were studied and the percentage removal of residues in each treatment is presented below.

Table 18: Comparison of open pan and closed pan cooking in peppermint leaves

Treatments	Mean per cent removal of organophosphate insecticides (%) *± SD								
	Dimethoate	Chlorpyriphos	Quinalphos	Profenophos	Ethion	Bifenthrin	Lambda-cyhalothrin	Cypermethrin	Fenvalerate
T1- washing +cooking (closed pan)	32.11 ± 0.99	30.52 ± 1.19	43.16 ±3.53	30.14 ± 2.25	33.16±0.20	58.89 ±3.21	50.44±4.51	43.36±4.25	54.41±3.07
T2- washing + cooking (open pan)	33.75±0.86	33.24 ± 1.37	47.04 ±3.34	38.61 ± 2.92	39.82±3.11	54.97 ±2.30	45.92±5.69	40.40±4.92	56.71±0.72
t (0.05)	(1.016)	(0.406)	(0.724)	(1.298)	(1.810)	(1.524)	(1.077)	(0.788)	(1.904)

* Mean of three replications

4.2.2.1 Effect of Different Washing Solutions on the Removal of Organophosphate Insecticide Residues

The results of 4.2.2.1 are presented in Table19

4.2.2.1.1 Dimethoate

All the decontamination treatments varied in their efficacy in reducing the residue load on coriander leaves. Immersing the leaves in KAU Veggie wash (10 mL L^{-1}), two per cent turmeric solution and two per cent synthetic vinegar solution were the most effective treatment, which removed 50.49, 45.98 and 46.68 per cent of the residues respectively. This was followed by dipping in tap water, two per cent common salt solution and two per cent tamarind solution, which resulted in 38.3, 37.2 and 30.18 per cent reduction respectively.

4.2.2.1.2 Quinalphos

All the decontaminating treatments removed quinalphos residues seen on coriander leaves one day after spraying to the tune of 40 to 55 per cent. Dipping the leaves in two per cent synthetic vinegar solution, two per cent turmeric solution and KAU Veggie wash (10 mL L^{-1}) for five minutes followed by three washing in water were on par in their efficacy in removing the residues, to the tune of 53.10, 55.10, and 54.70 per cent respectively. Similarly when the leaves were dipped in two per cent common salt solution and two per cent tamarind solution followed by three washing in plain water, reduced the residues up to 45.12 and 44.60 per cent respectively. Dipping in tap water alone for five minutes reduced only 40.23 per cent of residues.

4.2.2.1.3 Chlorpyriphos

All the decontamination treatments differed significantly in their efficacy in removing chlorpyriphos residues. The best three treatments were dipping the

Table 19: Extent of removal of residues of organophosphate insecticides from coriander leaves after dipping in different solutions

Treatments	Mean per cent removal of insecticides (%)** ± SD				
	Dimethoate	Quinalphos	Chlorpyriphos	Profenophos	Ethion
T1-2% tamarind paste*	30.18 ± 10.50(5.53)^{c}	44.6 ± 3.91(6.74)^{b}	67.78 ± 3.52(8.19)^{b}	52.59 ± 2.36(7.31)^{bc}	39.20 ±3.32(6.33)^{b}
T2-2% common salt*	37.2 ± 4.42(6.17)^{bc}	45.1 ± 3.22(6.78)^{b}	68.51 ± 3.14(8.33)^{b}	49.96 ± 4.79(7.13)^{bc}	45.01 ±9.81(6.75)^{b}
T3- 2% turmeric powder*	45.98 ± 4.69(6.84)^{ab}	55.1 ± 3.30(7.48)^{a}	72.81 ± 3.39(8.58)^{ab}	50.80 ± 3.83(7.19)^{bc}	53.88 ±9.04(7.39)^{b}
T4- 2% synthetic vinegar *	46.68 ± 1.43(6.90)^{ab}	53.1 ± 1.43(7.35)^{a}	74.85 ± 3.45(8.70)^{ab}	58.25 ±4.13(27.66)^{ab}	76.56 ±3.97(8.80)^{a}
T5- KAU Veggie wash 10mlL^{-1} *	50.49 ± 2.52(7.17)^{a}	54.7 ± 3.25(7.46)^{a}	76.17 ± 5.02(8.78)^{a}	63.7± 2.19(8.04)^{a}	81.11 ± 1.84(9.06)^{a}
T6- tap water*	38.3 ± 1.90(6.26)^{bc}	40.2 ± 2.06(6.41)^{b}	61.24 ± 4.45(7.88)^{c}	45.42 ± 4.32(6.80)^{c}	21.39 ±9.80(4.64)^{c}
CD(0.05)	(0.791)	(0.376)	(0.426)	(0.714)	(1.093)

Values shown in parentheses are $\sqrt{x+1}$ transformed values. Values are significantly different from each other by LSD at 5 %
*Subjected to dipping in treatment solutions for 5 minutes followed by three normal washings
** Mean of three replications

leaves in KAU Veggie wash (10 mL L^{-1}), two per cent synthetic vinegar solution and two per cent turmeric solution for five minutes followed by three washing in tap water, with 76.17, 74.85 and 72.81 per cent reduction of residues respectively. Dipping in two per cent tamarind solution and two per cent common salt solution for five minutes followed by three washing recorded a removal of 67.78 and 68.51 per cent respectively. The least removal of residues (61.24 per cent) was observed in simple tap water washing.

4.2.2.1.4 Profenophos

The residues of profenophos detected one day after spraying were removed to varying extent by different decontamination treatments. Dipping of coriander leaves in two per cent synthetic vinegar solution and in KAU Veggie wash (10 mL L^{-1}) for five minutes were the most effective treatment, reducing the initial residue up to 58.25 and 63.70 per cent respectively. This was followed by two per cent tamarind solution, two per cent turmeric solution and two per cent common salt solution which removed 52.59, 50.80 and 49.96 per cent of the residues respectively. Based on percentage removal, it was statistically proved that there is a significant reduction in profenophos residue for all the decontaminating solutions when compared with washing in tap water (45.42 per cent).

4.2.2.1.5 Ethion

All the decontamination treatments differed significantly in their efficacy in removing ethion residues. The superior treatments were dipping the leaves for five minutes in two per cent synthetic vinegar solution (76.56per cent) and KAU veggie wash 10 mL L^{-1} (81.11per cent) followed by three washing in tap water. Both the treatments were on par in their effect. Dipping in two per cent turmeric solution, two per cent common salt solution and two per cent tamarind solution for five minutes followed by three washing removed 53.88, 45.01, and 39.20 per cent of residues respectively. The lowest per cent removal of residue (21.39 per cent) was observed when the leaves were dipped in tap water alone for five minutes.

4.2.2.2 Effect of Different Washing Solutions on the Removal of Synthetic Pyrethroid Insecticide Residues

The results of 4.2.2.2 are presented in Table 20

4.2.2.2.1 Bifenthrin

Dipping in two per cent synthetic vinegar solution and KAU Veggie wash (10 mL L^{-1}) for five minutes followed by three washing in water were the best treatments for removing bifenthrin residues from coriander leaves. The extent of reduction recorded was 50.95 per cent in KAU Veggie wash 10 mL L^{-1} and 46.44 per cent in two per cent synthetic vinegar solution and both the treatments were on par. Dipping in two per cent salt solution, plain water, two per cent tamarind solution and two per cent turmeric solution could remove only 36.10, 28.72, 24.57 and 22.95 per cent of residues respectively.

4.2.2.2.2 Lambda cyhalothrin

Dipping in the solution of two per cent synthetic vinegar, two per cent turmeric solution, KAU Veggie wash 10 mL L^{-1} for five minutes followed by three washing could remove 29.68, 26.60 and 25.41 per cent of residues. All other treatments *viz.,*, two per cent tamarind solution, simple washing in tap water and two per cent salt solution reduced 16.51, 16.50 and 14.2 per cent of residues respectively.

4.2.2.2.3 Cypermethrin

The decontamination treatments were less effective in removing the cypermethrin residue load on coriander leaves. Among all decontamination treatments, more than 30 per cent removal was observed only in the treatments like dipping the leaves in two per cent synthetic vinegar solution (30.50 per cent) and KAU Veggie wash 10 mL L^{-1} (31.00 per cent) for 5 minutes. Other

Table20: Extent of removal of residues of synthetic pyrethroid insecticides from coriander leaves after dipping in different solutions

Treatments	Mean per cent removal of insecticides (%)** ± SD			
	Bifenthrin	Lambda-cyhalothrin	Cypermethrin	Fenvalerate
T1-2% tamarind paste*	24.57 ±3.60(5.04)^{bc}	16.51±2.31(4.17)^{b}	14.61±3.32(5.35)^{b}	26.30±5.85(5.21)^{b}
T2-2% common salt*	36.10±17.8(6.39)^{c}	14.22±1.43(3.88)^{b}	15.52±5.12(5.28)^{b}	24.83±2.87(5.07)^{bc}
T3- 2% turmeric powder*	22.95±4.20(5.34)^{b}	26.60±3.97(5.24)^{a}	14.80±1.20(5.33)^{b}	29.51±0.52(5.52)^{b}
T4- 2% synthetic vinegar *	46.44±3.43(7.12)^{a}	29.68±4.9(5.52)^{a}	30.50±1.87(4.34)^{a}	38.61±5.49(6.28)^{a}
T5- KAU Veggie wash $10 mlL^{-1}$ *	50.95±4.75(7.48)^{a}	25.41±11.01(5.06)^{a}	31.00±5.21(4.31)^{a}	40.20±3.18(6.41)^{a}
T6- tap water*	28.72±6.40(5.85)^{bc}	16.50±1.63(4.18)^{b}	12.51±6.05(5.40)^{b}	19.12±5.35(4.44)^{c}
CD(0.05)	(0.731)	(0.606)	(0.963)	(0.756)

Values shown in parentheses are $\sqrt{x+1}$ transformed values. Values are significantly different from each other by LSD at 5 %
*Subjected to dipping in treatment solutions for 5 minutes followed by three normal washings
** Mean of three replications

decontamination treatments like two per cent salt solution, two per cent turmeric solution, two per cent tamarind solution and simple washing in tap water reduced only 15.52, 14.80, 14.61 and 12.51 per cent of residues respectively.

4.2.2.2.4 Fenvalerate

The percentage removal of fenvalerate residues from coriander leaves when subjected to different decontamination solutions at one day after spraying showed that dipping in KAU Veggie wash (10 mL L^{-1}) and two per cent synthetic vinegar solution for five minutes were found to remove 40.20 and 38.61 per cent of residues respectively. It was proved that these treatments were statistically on par. However, dipping in two per cent turmeric solution (29.51 per cent), two per cent tamarind solution (26.30 per cent) and two per cent common salt solution (24.83 per cent) were less effective when compared to other treatments. Whereas tap water removes only 19.12 per cent of fenvalerate residues.

4.2.2.3 ***Effect of different cooking treatments on the removal of organophosphate insecticides residues***

The results of 4.2.2.3 are presented in Table 21

4.2.2.3.1 Dimethoate

The percentage removal of dimethoate residues from coriander leaves when cooked in closed pan for ten minutes after dipping in different decontamination solutions for five minutes at one day after spraying showed that KAU Veggie wash (10 mL L^{-1}) plus cooking and two per cent synthetic vinegar solution plus cooking was found to be most effective in removing 55.44 and 54.31 per cent of residues respectively. The next promising treatments were dipping in two per cent turmeric solution plus cooking (44.51 per cent), two per cent tamarind solution plus cooking (43.85 per cent) and two per cent common salt solution plus cooking (42.19 per cent). These treatments were statistically on par. However,

Table 21: Extent of removal of residues of organophosphate insecticides from coriander leaves (different dipping plus cooking)

Treatments	Mean per cent removal of insecticides (%)** ± SD				
	Dimethoate	Quinalphos	Chlorpyriphos	Profenophos	Ethion
T1- 2% tamarind* + cooking (closed pan)	43.85 ± 6.25(6.61)^{b}	74.59 ± 2.54(8.63)^{b}	55.90±1.9(7.48)^{b}	43.85±2.79(7.66)^{b}	50.19±2.90(7.08)^{c}
T2- 2% common salt* + cooking (closed pan)	42.19 ± 6.44(6.48)^{b}	71.47±3.35(8.45)^{bc}	46.23s±1.1(6.80)^{c}	42.19±3.46(7.71)^{c}	57.85±1.04(7.60)^{c}
T3- 2% turmeric* + cooking (closed pan)	44.51 ± 1.04(6.67)^{b}	76.47±0.82(8.74)^{b}	55.7±1.5(7.46)^{b}	44.51±1.58(8.12)^{b}	59.41±3.24(7.70)^{bc}
T4- 2% vinegar* + cooking (closed pan)	54.31 ± 4.42(7.36)^{a}	86.63±2.76(9.30)^{a}	59.40±6.1(7.69)^{ab}	54.31±1.46(8.39)^{a}	80.32±5.04(8.95)^{a}
T5- KAU Veggie wash at 10 ml L^{-1}*+ cooking (closed pan)	55.44±4.81(7.44)^{a}	83.30±3.04(9.13)^{a}	63.62±2.8(7.97)^{a}	55.44±0.9(8.63)^{a}	73.94±4.98(5.95)^{ab}
T6- tap water* + cooking (closed pan)	24.49±2.19 (5.68)^{c}	67.59 ±5.87(8.21)^{c}	42.36±2.3(6.50)^{c}	32.29±1.35(7.47)^{c}	36.40±14.19(0.55)^{d}
CD(0.05)	(0.456)	(0.367)	(0.371)	(0.249)	(0.951)

Values shown in parentheses are $\sqrt{x+1}$ transformed values. Values are significantly different from each other by LSD at 5 %.
*Subjected to dipping in treatment solutions for 5 minutes followed by three normal washings
** Mean of three replications

the percentage residue removal through dipping in tap water for five minutes plus cooking (24.49 per cent) was significantly lower compared to other treatments.

4.2.2.3.2 Quinalphos

The quinalphos residues were removed to a higher extent by different cooking treatments compared to other insecticides. Cooking coriander leaves in closed pan for 10 minutes after dipping in two per cent synthetic vinegar solution (86.63 per cent) and KAU Veggie wash 10 mL L^{-1} (83.30 per cent) for five minutes showed comparatively higher extent of reduction of quinalphos residues. All other treatments such dipping in two per cent turmeric plus cooking (closed pan), two per cent tamarind plus cooking (closed pan), two per cent common salt solution plus cooking (closed pan) and tap water plus cooking 67.59 were proved to be statistically on par which facilitate a removal of 76.47, 74.59 and 71.47 per cent respectively.

4.2.2.3.3 Chlorpyriphos

The superior treatment for removing chlorpyriphos residue was dipping the leaves for five minutes in KAU Veggie wash 10 mL L^{-1} (63.62 per cent) followed by cooking in closed pan for 10 minutes. Similarly, cooking in closed pan after dipping the leaves in two per cent synthetic vinegar solution reduced 59.40 per cent of residues. The losses incurred due to other cooking treatments were 55.90 per cent (2 per cent tamarind solution plus cooking), 55.70 per cent (2 per cent turmeric plus cooking) and 46.23 (2 per cent common salt solution plus cooking). Overall, a significant reduction in chlorpyriphos residues was observed for cooking after dipping in different solutions when compared with washing in tap water plus cooking (42.36 per cent).

4.2.2.3.4 Profenophos

Cooking of coriander leaves for 10 minutes in closed pan after dipping in KAU veggie wash 10 mL L^{-1} and in two per cent synthetic vinegar solution for five minutes facilitated the removal of 55.44 and 54.31 per cent residues of profenophos respectively. These cooking treatments were statistically proved to be the best for reducing profenophos residues and it was closely followed by dipping in two per cent tamarind solution plus cooking (43.85 per cent) and two per cent turmeric plus cooking (44.51 per cent). More or less similar percentage of residue removal was noticed in dipping in two per cent common salt solution plus cooking (42.19per cent) and tap water plus cooking (32.29 per cent).

4.2.2.3.5 Ethion

Cooking of coriander leaves for 10 minutes in closed pan after dipping in different solutions were found to be highly effective in removing ethion residues. Among all cooking treatments, the superior treatments for removing ethion residues were dipping the leaves in KAU veggie wash 10 mL L^{-1}plus cooking (73.94per cent) and two per cent synthetic vinegar solution plus cooking for 10 minutes (80.32 per cent). The next promising treatments were dipping in two per cent turmeric powder plus cooking (59.41per cent), two per cent common salt solution plus cooking (57.85 per cent) and two per cent tamarind solution plus cooking (50.19 per cent) for 10 minutes in closed pan. Only 36.40 per cent residue was removed when the leaves were cooked after dipping in plain water for five minutes.

4.2.2.4 Effect of Different Cooking Treatments on the removal of Synthetic Pyrethroid Insecticide Residues

The results of 4.2.2.4 are presented in Table 22

4.2.2.4.1 Bifenthrin

Cooking of coriander leaves for 10 minutes in closed pan after dipping in two per cent turmeric solution, two per cent synthetic vinegar solution and KAU veggie wash 10 mL L^{-1} for five minutes facilitated the removal of 58.62, 56.18 and 56.03 per cent of bifenthrin residues respectively. Whereas, dipping in other

Table 22: Extent of removal of residues of synthetic pyrethroid insecticides from coriander leaves (different dipping plus cooking)

Treatments	Mean per cent removal of insecticides (%)** ± SD			
	Bifenthrin	Lambda cyhalothrin	Cypermethrin	Fenvalerate
T1- 2% tamarind* + cooking (closed pan)	38.47±6.49(6.18)^{b}	22.47±3.74(0.32)^{d}	20.93±8.14 (4.94)^{bc}	55.99 ±1.90(3.50)^{c}
T2- 2% common salt* + cooking (closed pan)	32.60±2.12(5.70)^{b}	27.97±8.63(0.31)^{c}	18.84±11.7(5.05)^{c}	46.25 ±1.12(4.27)^{c}
T3- 2% turmeric* + cooking (closed pan)	58.62±7.77(7.64)^{a}	34.22±5.33(0.30)^{b}	17.94±1.71 (5.13)^{c}	55.77±1.50(3.5)^{b}
T4- 2% vinegar* + cooking (closed pan)	56.18±0.78(7.49)^{a}	41.10±8.90(0.27)^{a}	33.17±2.55 (4.18)^{ab}	59.37±6.14(3.2)^{a}
T5- KAU Veggie wash at 10 ml L^{-1}*+ cooking (closed pan)	56.03±4.17(7.48)^{a}	43.17±10.2(0.26)^{a}	36.14±8.41 (3.99)^{a}	63.68 ± 2.80(2.8)^{a}
T6- tap water* + cooking (closed pan)	34.75±4.15(5.88)^{b}	18.52±8.66(0.33)^{e}	14.15±3.24 (5.37)^{c}	42.36±2.33(4.58)^{d}
CD(0.05)	(0.649)	(0.382)	(1.333)	(0.292)

Values shown in parentheses are $\sqrt{x+1}$ transformed values. Values are significantly different from each other by LSD at 5 %

*Subjected to dipping in treatment solutions for 5 minutes followed by three normal washings

** Mean of three replications

decontamination solutions followed by cooking resulted in less than 40 per cent removal of residues *i.e.,* two per cent tamarind solution plus cooking (38.47 per cent), two per cent common salt solution plus cooking (32.60 per cent) and tap water plus cooking (34.75 per cent).

4.2.2.4.2 Lambda cyhalothrin

All the decontamination treatments varied in their efficacy in removing Lambda cyhalothrin residues. Among all treatments, highest removal was observed in dipping the leaves in KAU Veggie wash for five minutes followed by cooking (43.17 per cent) and in two per cent vinegar solution followed by cooking (41.10 per cent) for 10 minutes in closed pan. The treatments which gave the least removal of residues were dipping in two per cent turmeric solution plus cooking (34.22 per cent), two per cent common salt solution plus cooking (27.97 per cent), two per cent tamarind plus cooking (22.47 per cent) and in tap water plus cooking (36.49 per cent).

4.2.2.4.3 Cypermethrin

The percentage removal of cypermethrin residues from coriander leaves when subjected to different cooking treatments showed that dipping in KAU Veggie wash (10 mL L^{-1}) plus cooking and two per cent synthetic vinegar solution plus cooking for 10 minutes were found to be statistically superior in removing 36.14 and 33.17 per cent of residues respectively, both treatments being statistically on par. All other treatments like two per cent tamarind solution plus cooking, two per cent common salt solution plus cooking, two per cent turmeric solution plus cooking and simple washing in tap water plus cooking reduced only 20.93, 18.84, 17.94 and 14.15 per cent of residues respectively.

4.2.2.4.4 Fenvalerate

The percentage removal of fenvalerate residues from peppermint leaves when subjected to different cooking treatments showed that dipping in KAU

Table 23: Comparison of open pan and closed pan cooking in coriander leave

Treatments	Mean per cent removal of insecticides (%) *± SD								
	Dimethoate	Chlorpyriphos	Quinalphos	Profenophos	Ethion	Bifenthrin	Lambda-cyhalothrin	Cypermethrin	Fenvalerate
T1- washing +cooking (closed pan)	22.57 ± 1.68	42.36 ± 2.30	67.59 ± 5.86	33.22 ± 2.18	36.40±1.14	34.75 ± 4.15	18.33 ±0.73	14.15 ± 3.23	54.95 ± 1.35
T2- washing + cooking (open pan)	25.97 ± 3.16	43.56 ± 1.05	63.65 ± 3.12	32.19 ± 1.63	40.71±2.39	35.38 ± 1.61	20.44 ±1.70	17.92 ± 2.50	54.77 ± 2.11
t (0.05)	(1.64)	(0.82)	(1.02)	(0.84)	(0.52)	(0.17)	(1.95)	(1.59)	(0.12)

* Mean of three replications

Veggie wash (10 mL L^{-1}) plus cooking for 10 minutes in closed pan was found to be most effective in removing 63.68 per cent of residues. Similar result was obtained for dipping the leaves in two per cent synthetic vinegar solution for five minutes followed by cooking for ten minutes in closed pan (59.37 per cent). These two treatments were statistically on par. Dipping in two per cent tamarind solution plus cooking (55.99 per cent), two per cent turmeric solution plus cooking (55.77 per cent), two per cent common salt solution plus cooking (46.25 per cent) and simple washing plus cooking (42.36 per cent) were found to be statistically on par.

4.2.2.5 Effect of Open Pan and Close Pan Cooking Treatments on the Removal of Insecticide Residues

Removal of residues from coriander leaves when cooked in closed pan and open pan did not differ significantly for all the insecticides tested (Table 23).

4.3 ASSESSING THE EFFECT OF DIFFERENT HOUSEHOLD PRACTICES ON THE REMOVAL OF PESTICIDE RESIDUE FROM RED CHILLI (DRY)

The effect of different decontamination treatments in removing the residues of organophosphate and synthetic pyrethroid insecticides from red chilli were studied and the percentage removal of residues in each treatment is presented below.

4.3.1 Organophosphate Insecticides

The results of 4.3.1 are presented in Table 24

4.3.1.1 Dimethoate

All the decontamination treatments differed significantly in their efficiency in removing dimethoate residues from red chilli. Cooking chilli

Table 24: Extent of removal of residues of organophosphate insecticides from red chilli

Treatments	Mean per cent removal of insecticides (%)* ± SD				
	Dimethoate	Quinalphos	Chlorpyriphos	Profenophos	Ethion
T1- Dipping dry chilli fruits in curd and salt	68.08 ± 4.3 (8.24)^{b}	83.64 ± 1.3(9.14)^{ab}	16.10 ± 7.5 (3.94)^{bc}	68.02±35.5 (8.24)^{ab}	24.12±1.5(4.90)^{d}
T2- Powdering as such	2.25 ± 2.11 (1.49)^{f}	8.07 ± 1.00(2.84)^{e}	2.54 ± 3.20 (1.58)^{d}	- 6.10 ±1.11 (2.46)^{d}	0.36 ± 5.33 (0.52)^{f}
T3- Removal of fruit stalk and powdering whole fruits	17.73 ± 3.5 (4.19)^{d}	75.01 ± 0.8 (9.79)^{b}	20.65 ± 3.8 (4.53)^{b}	64.20±2.1 (8.61)^{b}	33.26±4.1 (5.76)^{c}
T4- Powdering of fruits after removal of seeds	6.80 ± 2.7(2.57)^{e}	11.61 ± 5.6 (3.33)^{e}	9.40 ± 0.8(3.06)^{c}	5.57±4.9(2.20)^{d}	7.64±3.2(2.76)^{e}
T5- Sauting of dry chilli in frying pan for 2 minutes	72.59 ± 0.7 (8.52)^{b}	22.74 ± 5.4 (4.74)^{d}	46.48 ± 2.8 (6.81)^{a}	68.97±4.3 (6.23)^{c}	64.81 ±2.5(6.53)^{b}
T6- Cooking chilli powder in water for 20 minutes	85.54 ± 0.7 (9.24)^{a}	65.01 ±11.8(8.03)^{c}	52.72 ± 12.0(7.23)^{a}	81.68±10.2 (9.02)^{a}	66.40±0.7 (8.14)^{a}
T7- KAU veggie wash at 10 mlL^{-1}	69.79 ± 6.8(8.34)^{b}	89.5±1.49 (9.45)^{ab}	23.44 ± 7.01(4.80)^{b}	72.35 ±5.44(8.50)^{ab}	20.79±5.6 (4.50)^{d}
T8- Simple washing	48.28 ± 3.4 (6.94)^{c}	60.8 ±2.59 (8.99)^{c}	16.31 ± 3.4(4.02)^{bc}	65.0±2.28 (8.06)^{b}	11.08±5.05 (3.32)^{e}
CD (0.05)	0.583	1.052	1.051	0.816	0.661

Values shown in parentheses are $\sqrt{x+1}$ transformed values. Values are significantly different from each other by LSD at 5 %

*Subjected to dipping in treatment solutions for 5 minutes followed by three normal washings

** Mean of three replications

powder in water for 20 minutes was found to be effective in removing upto 85.54 per cent of dimethoate residues. Similarly sauting of dry chilli in frying pan for two minutes reduced 72.59 per cent and dipping dry chilli fruits in curd and salt reduced 68.08 per cent of dimethoate residues respectively. The treatments such as powdering red chilli as such (2.25 per cent), powdering after removal of fruit stalk (17.73 per cent) and powdering after removal of seeds (6.80 per cent) were not effective in the removal of dimethoate residues as the percentage removal was less than 20 per cent only. A significant reduction in the residue was observed when fruits were dipped in KAU Veggie wash 10 mL L^{-1} for five minutes (69.79 per cent) when compared with dipping for five minutes in tap water (48.28 per cent).

4.3.1.2 Quinalphos

Significant reduction in residue was recorded when red chilli sprayed with quinalphos was subjected to different decontamination treatments. Dipping the fruits in KAU Veggie wash 10 mL L^{-1} (89.52 per cent) for five minutes followed by three washing was the promising treatment in decontaminating quinalphos residues and it was closely followed by dipping dry chilli in curd and salt with 83.64 per cent removal. Dipping in tap water for five minutes followed by three washing in tap water reduced 60.87 percent of residues. Cooking chilli powder in water for 20 minutes removed 65.01 per cent of quinalphos residues. Powdering red chilli after removing the stalk resulted in 75.01 per cent reduction in residues. However other powdering treatments *viz.*, powdering red chilli as such (8.07 per cent), powdering after removal of seeds (11.61 per cent) and sauting of dry chilli in frying pan for two minutes (22.74 per cent) were found to be ineffective in removing the residues.

4.3.1.3 Chlorpyriphos

The extent of removal of chlorpyriphos residues from red chilli was more than 40 per cent removal only in the treatments like cooking chilli powder in water for 20 minutes (52.72 per cent) and sauting of dry chilli for two minutes (46.48 per cent). There was no significant reduction in residues for dipping the fruits in curd and salt (16.10 per cent) and KAU Veggie wash 10 mL L^{-1} (23.44 per cent) for five minutes. Powdering treatments *viz.,* powdering as such (2.54 per cent), powdering after removal of stalk (20.65) and after removing seed (9.40 per cent) was also found to be ineffective.

4.3.1.4 Profenophos

Treatments *viz.,* cooking chilli powder in water for 20 minutes and dipping dry chilli in curd and salt removed 81.68 and 68.02 per cent residues of profenophos respectively. Dipping of red chilli in KAU Veggie wash (10 mL L^{-1}) for five minutes followed by three washing, facilitated the removal of 72.35 per cent residues when compared to simple washing in tap water (65.00 per cent). Sauting of dry chilli in frying pan for two minutes could remove only 38.97 per cent of residues. Powdering red chilli after removing the stalk resulted in 64.20 per cent reduction of residues, however powdering whole fruits as such gave a negative value (-6.10 per cent) and powdering fruits after removing seeds recorded only 5.57 per cent removal of residues.

4.3.1.5 Ethion

Cooking of chilli powder in water for 20 minutes and sauting of dry chilli for two minutes showed significantly higher reduction of residues, to the tune of 66.40 and 64.81 per cent respectively. Treatments viz., powdering whole fruits as such, powdering after removal of fruit stalk and powdering after removal of seeds reduced ethion residues to the tune of 0.36, 33.26 and 7.64 per cent respectively. Dipping of red chilli in KAU Veggie wash (10 mL L^{-1}) for five minutes followed by three washing, resulted in the removal of 20.79 per cent residues whereas dipping dry chilli in curd and salt removed 24.12 per cent of residues. Simple washing of dry chilli reduced.

4.3.2 Synthetic Pyrethroid Insecticides

The results of 4.3.2 are presented in Table 25

4.3.2.1 Bifenthrin

The percentage removal of bifenthrin residues in red chilli was more than 50per cent when cooked for 20 minutes in water (59.99 per cent) and sauted for two minutes in frying pan (55.84 per cent). All the other treatments were less effective in the removal of bifenthrin residues. Dipping in KAU Veggie wash (10 mL L^{-1}) for five minutes followed by three washing resulted in only 26.10 per cent removal of residues, whereas other treatments like dipping in curd and salt, powdering whole fruits as such, powdering after removal of stalk, powdering after removal of seeds and simple washing could remove only 12.11, 2.38, 24.38, 11.18 and 20.74 per cent of residues.

4.3.2.2 Lambda cyhalothrin

In the case of Lambda cyhalothrin, highest removal of residue was observed in cooking chilli powder in water for 20 minutes (58.99per cent). The next promising treatment was sauting the dry chilli in frying pan for two minutes (47.22 per cent). Dipping red chilli in KAU Veggie wash (10 mL L^{-1}) for five minutes followed by three washing, dipping in tap water and dipping dry chilli in curd and salt could remove only 14.51, 11.06 and 5.82 per cent of residues respectively. Powdering red chilli after removing the stalk resulted in 26.31 per cent reduction of residues, however powdering whole fruits as such and powdering fruits after removing seeds could remove only 9.93 and 2.62 per cent of residues.

Table 25: Extent of removal of residues of synthetic pyrethroid insecticides from red chilli

Treatments	Mean per cent removal of insecticides (%)* ± SD			
	Bifenthrin	Lambda-cyhalothrin	Cypermethrin	Fenvalerate
T1- Dipping dry chilli fruits in curd and salt	12.11 ± 2.0(3.7)^{c}	5.82 ± 3.5 (2.30)^{e}	23.33 ±7.5 (4.81)^{d}	5.50 ± 2.2(2.34)^{cd}
T2- Powdering as such	2.38 ± 2.58(1.54)^{d}	9.93 ± 3.66(3.14)^{d}	1.12 ±1.00(1.06)^{f}	3.78 ± 2.11 (1.94)^{d}
T3- Removal of fruit stalk and powdering whole fruits	24.38 ± 3.3(3.18)^{b}	26.31 ± 3.6(5.12)^{c}	29.33 ± 1.2(5.39)^{cd}	25.12 ± 3.0(5.00)^{b}
T4- Powdering of fruits after removal of seeds and stalk	11.18 ± 2.6 (3.70)^{c}	2.62 ± 0.03(1.63)^{e}	19.66 ± 6.9(4.74)^{d}	1.28 ± 1.6(1.12)^{e}
T5- Sauting of dry chilli in frying pan for 2 minutes	55.84 ± 2.6(1.86)^{a}	47.22 ± 1.8(6.87)^{b}	35.00 ± 1.9(7.27)^{a}	59.48 ± 1.9 (7.71)^{a}
T6- Cooking chilli powder in water (20 minutes)	59.99 ± 7.1 (1.67)^{a}	58.99 ± 2.4(7.67)^{a}	35.86 ± 5.7 (6.66)^{ab}	64.34 ± 4.5 (8.01)^{a}
T7- KAU veggie wash at 10 mlL^{-1}	26.10 ± 4.24(3.19)^{b}	14.51± 1.53 (3.80)^{d}	14.66 ± 8.00(5.98)^{bc}	21.00 ± 8.33 (4.51)^{b}
T4- Simple washing	20.74 ± 2.11(4.55)^{b}	11.06 ± 1.66(3.31)^{d}	24.66± 1.19(3.79)^{d}	7.00 ± 5.33(2.64)^{c}
CD (0.05)	0.558	0.691	0.801	0.647

Values shown in parentheses are $\sqrt{x+1}$ transformed values. Values are significantly different from each other by LSD at 5 %
*Subjected to dipping in treatment solutions for 5 minutes followed by three normal washings
** Mean of three replications

4.3.2.3 Cypermethrin

The extent of removal of cypermethrin residues from red chilli through different decontaminating treatments was low compared to other insecticides. The percentage removal of cypermethrin residues in red chilli when cooked for 20 minutes in water and sauted for two minutes was 35.86 and 35.00 percent respectively. There was no significant reduction in residues for dipping the fruits in curd and salt (23.33 per cent). Dipping in KAU Veggie wash 10 mL L^{-1} (23.44 per cent) for five minutes is not effective when compared with simple washing with tap water (24.66 per cent). Powdering treatments were also found to be ineffective as the percentage removal when powdered as such, powdered after removal of stalk and powdered after removal of seeds were 1.12, 29.33 and 22.66per cent respectively.

4.3.2.4 Fenvalerate

The percentage removal of fenvalerate residues, when subjected to cooking chilli powder in water for 20 minutes was found to be effective in removing 64.34 per cent of residues. The next promising treatment was sauting of dry chilli in frying pan for two minutes (59.48 per cent). More or less similar per cent of residue removal was noticed in dipping in KAU Veggie wash 10 mL L^{-1}(21.00 per cent) and powdering of dry chilli after removal of stalk (25.12 per cent). All other treatments *viz.,* powdered as such, powdered after removal of seeds and dipping in curd and salt were found to be inferior with 3.78, 1.28 and 5.50 per cent removal of residues.

4.4 EFFECT OF DIFFERENT HOUSEHOLD PRACTICES ON THE REMOVAL OF PESTICIDE RESIDUES FROM CUMIN SEED AND FENNEL

4.4.1 Cumin Seed

The efficacy of different solutions of household products in removing residues from cumin seed are presented below.

4.4.1.1 Effect of Different Household Practices on the Removal of Organophosphate Insecticide Residues

The results of 4.4.1.1 are presented in Table 26

4.4.1.1.1 Dimethoate

The percentage removal of dimethoate residues in cumin seed when subjected to different decontamination solutions one after spraying showed that all the treatments significantly differed among each other in their efficiency in removing dimethoate residues. It has been found that dipping in two per cent synthetic vinegar and two per cent turmeric solution were found to be effective than other treatments. In this process, the residues could be reduced up to 26.88 and 23.72 per cent respectively. The percentage removal of dimethoate residues in cumin seed when dipped in other decontaminating solutions were 19.70 (KAU Veggie wash 10 mL L^{-1}), 19.56 (2 per cent common salt solution), 14.38 per cent (2 per cent tamarind solution) and 11.16 per cent (washing in tap water).

4.4.1.2 Quinalphos

Decontamination of quinalphos residues in cumin seed one day after spraying by different decontaminating solutions showed that all the treatments significantly differed among each other in their efficiency in removing quinalphos residues. Dipping in two per cent synthetic vinegar (57.28 per cent) showed comparatively higher reduction of quinalphos residues. The percentage removal of

Table 26: Extent of removal of residues of organophosphate insecticides from cumin seeds after dipping in different solutions

Treatments	Mean per cent removal of insecticides (%) **± SD				
	Dimethoate	Quinalphos	Chlorpyriphos	Profenophos	Ethion
T1 - 2% commercial tamarind paste *	14.38 ± 2.63(3.91)^{c}	28.73 ± 0.18 (5.45)^{bc}	22.13 ± 1.46 (4.70)^{c}	54.49 ± 4.46(7.44)^{c}	35.22 ± 3.11(6.01)^{bc}
T2 - 2% common salt *	19.56 ± 2.09(4.53)^{b}	36.6 ± 0.82 (6.13)^{b}	22.18 ± 0.92 (4.71)^{c}	61.14 ± 2.37 (7.88)^{b}	31.31 ± 2.94 (5.68)^{c}
T3 - 2% turmeric powder *	23.72 ± 2.71 (4.96)^{ab}	49.42 ± 0.30(7.10)^{b}	31.71 ± 1.79 (5.62)^{a}	61.64 ± 0.67(7.91)^{b}	37.50 ± 2.64(6.20)^{ab}
T4 - 2% synthetic vinegar *	26.88 ± 2.67 (5.27)^{a}	57.28 ± 12.9 (5.93)^{a}	33.40 ± 0.49 (5.77)^{a}	69.50 ± 1.37(8.39)^{a}	41.37 ± 2.26 (6.50)^{a}
T5 - KAU Veggie wash at 10 mlL^{-1}*	19.70 ± 2.69 (3.48)^{b}	36..65 ± 0.52 (4.96)^{b}	28.70 ± 0.82 (4.25)^{b}	61.84 ± 1.05(7.34)^{b}	32.17 ± 0.87(4.64)^{c}
T6 – Simple washing*	11.16 ± 1.62 (4.54)^{c}	23.6 ± 0.09 (6.13)^{c}	18.09 ± 1.06 (5.35)^{d}	52.97 ± 3.50(7.92)^{c}	20.57 ± 2.14(6.57)^{d}
CD(0.05)	0.495	0.413	0.193	0.317	0.37

Values shown in parentheses are $\sqrt{x+1}$ transformed values. Values are significantly different from each other by LSD at 5 %

*Subjected to dipping in treatment solutions for 5 minutes followed by three normal washings

** Mean of three replications

residues when dipped in other decontaminating solutions were 49.42 (2 per cent turmeric solution) 36.65 (KAU Veggie wash 10 mL L^{-1}), 36.60 (2 per cent common salt solution) and 28.73 per cent (2 per cent tamarind solution). Dipping in tap water for five minutes removed only 23.60 per cent of quinalphos residues.

4.4.1.3 Chlorpyriphos

The percentage removal of chlorpyriphos residues in cumin seed when subjected to different decontamination solutions one day after spraying showed that all the treatments significantly differed among each other. It has been found that dipping in two per cent synthetic vinegar solution (33.40 per cent) and two per cent turmeric solution (31.71 per cent) were found to be effective than other treatments. The percentage removal of residues when dipped in other decontaminating solutions were 22.13 per cent (2 per cent tamarind), 22.18 per cent (2 per cent common salt) 28.70 per cent (KAU Veggie wash 10 mL L^{-1}) and 18.09 per cent (tap water).

4.4.1.4 Profenophos

All the decontamination treatments differed significantly in their efficacy in removing profenophos residues. Dipping of cumin seed in two per cent synthetic vinegar solution for five minutes was the most effective treatment in reducing the initial residue up to 69.50 per cent. This was followed by KAU Veggie wash (10 mL L^{-1}), two per cent turmeric solution and two per cent common salt solution which removed 61.84 and 61.64 per cent of the residues respectively. Whereas dipping in two per cent tamarind solution and tap water for five minutes could remove only 54.49 and 52.97 percent of profenophos residue.

4.4.1.5 Ethion

Dipping cumin seeds in two per cent turmeric solution and two per cent synthetic vinegar solution for five minutes followed by three washing in tap water showed higher reduction of ethion residues up to 37.50 and 41.37 per cent respectively. Percentage removal of residues in case of two per cent common salt solution, KAU Veggie wash 10 mL L^{-1}, two per cent tamarind solution and tap water were 31.31, 32.17, 35.22 and 20.57 per cent respectively.

4.4.1.2 Effect of Different Household Practices on the Removal of Synthetic Pyrethroid Insecticide Residues

The results of 4.4.1.2 are presented in Table 27.

4.4.1.2.1 Bifenthrin

Dipping in two per cent synthetic vinegar solution for five minutes resulted in 38.78 per cent removal of bifenthrin residues from cumin seed one day after spraying and this treatment was significantly superior over all the other treatments. There was no significant difference in percentage removal of bifenthrin residues when dipped in KAU Veggie wash 10 mL L^{-1} (32.97 per cent) and dipped in two per cent common salt solution (30.44 per cent). Percentage reduction of residues when dipped for five minutes in two per cent turmeric solution, two per cent tamarind solution and tap water were 21.36, 17.36 and 14.64 per cent respectively.

4.4.1.2.2 Lambda cyhalothrin

In the case of Lambda cyhalothrin, percentage removal of residues in all the treatments showed statistical difference from unprocessed samples ranging from 10.03 to 44.23 per cent. Among all treatments, highest removal was observed in dipping the seeds in two per cent turmeric solution (44.23 per cent) for five minutes followed by three washing in tap water. There was no significant reduction in residue for all the other decontaminating solutions like dipping the seeds for five minutes in two per cent synthetic vinegar solution (32.47 per cent), KAU Veggie wash 10 mL L^{-1} (30.71 per cent) , two per cent tamarind solution (15.33per cent) and two per cent common salt solution solution (25.90 per cent)

Table 27: Extent of removal of residues of synthetic pyrethroid insecticides from cumin seeds after dipping in different solutions

Treatments	Mean per cent removal of insecticides (%)** ± SD			
	Bifenthrin	Lambda-cyhalothrin	Cypermethrin	Fenvalerate
T1 - 2% commercial tamarind paste *	17.36 ± 3.16(4.27)[d]	15.33 ± 0.98(4.03)[d]	14.27 ± 2.90 (3.89)[d]	36.17 ± 1.59(6.01)[c]
T2 - 2% common salt *	30.44 ± 0.55(5.60)[b]	25.90 ± 1.02(5.18)[c]	17.63 ± 0.99(4.31)[c]	48.70 ± 1.07(6.97)[b]
T3 - 2% turmeric powder*	21.36 ± 0.96(4.72)[c]	44.23 ± 0.81(6.72)[a]	23.67 ± 2.73(4.96)[b]	72.46 ± 1.67(8.51)[a]
T4 - 2% synthetic vinegar*	38.78 ± 1.30(6.30)[a]	32.47 ± 1.16(5.78)[b]	31.51 ± 0.49(5.70)[a]	49.87 ± 1.09(7.06)[b]
T5 - KAU Veggie wash at 10 mlL^{-1}*	32.97 ± 0.92(3.94)[b]	30.71 ± 8.18(3.31)[b]	19.27 ± 2.10(3.66)[c]	55.00 ± 7.13(7.40)[b]
T6 – Simple washing*	14.64 ± 2.67(5.82)[d]	10.03 ± 1.27(5.62)[e]	12.47 ± 1.55(4.49)[d]	25.56 ± 5.00(5.03)[d]
CD(0.05)	0.089	0.631	0.432	0.520

Values shown in parentheses are $\sqrt{x+1}$ transformed values. Values are significantly different from each other by LSD at 5 %
*Subjected to dipping in treatment solutions for 5 minutes followed by three normal washings
** Mean of three replications

for five minutes. The treatment which gives the least removal was dipping in tap water (10.03per cent).

4.4.1.2.3 Cypermethrin

Among all decontamination treatments, the superior treatment for removing cypermethrin residues was dipping the seeds for five minutes in two per cent synthetic vinegar solution followed by three washing in tap water (31.51 per cent). All the other decontamination treatments resulted in only less than 30per cent removal of cypermethrin residues. Percentage reduction in residues when dipped in two per cent turmeric solution, KAU Veggie wash 10 mL $L^{-1}$and two per cent common salt solution were 23.67' 19.27 and 17.63 per cent respectively. The treatments with least removal were dipping in two per cent tamarind solution (14.27 per cent) and tap water (12.47 per cent) for five minutes.

4.4.1.2.4 Fenvalerate

The percentage removal of fenvalerate residues from cumin seeds when subjected to different decontamination solutions at one day after spraying showed that dipping in two per cent turmeric solution for five minutes followed by three washing in tap water was found to be most effective in removing up to 62.46 per cent of residues. The next promising treatments were dipping in KAU Veggie wash 10 mL L^{-1} (55.00 per cent), two per cent synthetic vinegar solution (49.87 per cent) and two per cent common salt solution (48.70 per cent). It was also proved that these treatments were statistically on par. However, the percentage residue removal through dipping in two per cent tamarind solution (36.17 per cent) and in tap water (25.56 per cent) was less compared to other treatments.

4.4.1.3 : Percentage Retention of Insecticides in Cumin Seed after Boiling with Water

The percentage retention of residues of organophosphates *viz.,* dimethoate, quinalphos, chlorpyriphos, profenophos, ethion in cumin seed after boiling were

Table 28: Percentage retention of insecticides in cumin seed after boiling with water

Treatments	Percentage insecticide retention								
	Dimethoate	Quinalphos	Chlorpyriphos	Profenophos	Ethion	Bifenthrin	Lambda-cyhalothrin	Cypermethrin	Fenvalerate
Cumin seed alone (after boiling)	27.00±0.51	76.22±0.711	57.39±2.15	64.46±1.55	78.18±2.5	35.93±2.49	77.30±0.80	86.16±2.13	63.08±4.20
Cumin water (after boiling)	9.00±0.22	46.34±1.87	36.63±3.15	25.23±2.79	34.54±3.92	9.77±0.55	34.66±1.68	53.30±3.02	23.01±1.95
t(0.05)	(56.685)	(25.828)	(9.408)	(21.256)	(16.157)	(17.744)	(39.68)	(15.281)	(14.820)

by different decontamination solutions showed that all the treatments significantly differed among each other in their efficiency in removing quinalphos residues. Dipping in two per cent synthetic vinegar solution (47.17 per cent) showed highest reduction of quinalphos residues. The percentage removal of residues when dipped in other decontamination solutions were 30.07 per cent (2 per cent turmeric solution), 33.20 per cent (KAU Veggie wash 10 mL L^{-1}), 27.50 per cent (2 per cent common salt solution) and 14.79 per cent (2 per cent tamarind solution). Dipping in tap water for five minutes removed only 12.20 per cent of quinalphos residues.

4.4.2.1.3 Chlorpyriphos

The percentage removal of chlorpyriphos residues in fennel when subjected to different decontamination solutions one day after spraying showed that all the treatments significantly differed among each other. Highest reduction in residue was observed in dipping the seeds in two per cent synthetic vinegar solution for five minutes followed by three washing in tap water (46.64per cent). The percentage removal of residues when dipped in other decontaminating solutions were 37.07 per cent (2 per cent turmeric solution), 13.87 per cent (2 per cent tamarind solution), 25.37 per cent (2 per cent common salt) 34.71 per cent (KAU Veggie wash 10 mL L^{-1}) and 9.26 per cent (tap water).

4.4.2.1.4 Profenophos

Dipping of fennel in two per cent turmeric solution for five minutes was the most effective treatment in reducing the residues upto 67.64 per cent. This was followed by dipping in synthetic vinegar solution for five minutes which removed 59.30 per cent of the residues. Percentage reduction in profenophos residue for all the other decontamination solution *viz.*, dipping in two per cent tamarind solution, two per cent common salt solution, KAU Veggie wash (10 mL L^{-1}) and tap water were 51.02 , 39.84 , 37.91 and 18.73 per cent respectively.

27.00, 76.22, 57.39, 64.46 and 78.18 per cent respectively (Table 28) Whereas percentage retention of residues of organophosphates *viz.,* dimethoate, quinalphos, chlorpyriphos, profenophos, ethion in water after boiling were 9.00, 46.34, 36.63, 25.23 and 34.54 per cent respectively. Similar trend was observed in synthetic pyrethroid insecticides *viz.,* bifenthrin, lambda cyhalothrin, cypermethrin and fenvalerate , where percentage retention in cumin seeds after boiling were 35.93, 77.30, 86.16 and 63.08 respectively. Percentage retention in water after boiling was 9.77, 34.66, 53.33 and 23.01 respectively.

4.4.2 Fennel

The efficacy of different solutions of household products in removing residues from fennel is presented below.

4.4.2.1 *Effect of Different Washing Solutions on the Removal of Organophosphate Insecticide Residues*

The results of 4.4.2.1 are presented in Table 29

4.4.2.1.1 Dimethoate

The decontamination treatments varied in their efficacy in reducing the residue load on fennel. Immersing the seeds in two per cent turmeric solution and two per cent synthetic vinegar solution for five minutes followed by three washing in tap water were effective in removing 53.60 and 56.57 per cent of the residues respectively. When fennel seeds were dipped in KAU Veggie wash (10 mL L^{-1}) for five minutes followed by three washings, only 34.88 per cent of dimethoate residues could be removed. All other treatments *viz.,* two per cent tamarind solution (9.75 per cent), two per cent common salt (6.87 per cent) and in tap water (5.23 per cent) were ineffective in the removal of dimethoate residues.

4.4.2.1.2 Quinalphos

Decontamination of quinalphos residues in fennel one day after spraying

Table 29: Extent of removal of residues of organophosphate insecticides from fennel after dipping in different solutions

Treatments	Mean per cent removal of insecticides (%) **± SD				
	Dimethoate	Quinalphos	Chlorpyriphos	Profenophos	Ethion
T1 - 2% commercial tamarind paste *	9.75 ± 2.64(3.26)^{c}	14.79 ± 2.21 (3.96)^{c}	13.87 ± 1.93 (3.85)^{d}	51.02 ± 4.67(3.18)^{c}	21.26 ±7.45(3.26)^{b}
T2 - 2% common salt *	6.87 ± 2.66 (2.77)^{cd}	27.50 ± 0.43(10.3)^{b}	25.37 ± 6.27 (5.11)^{c}	39.84 ± 1.67(3.50)^{d}	17.66 ± 8.53 (2.77)^{b}
T3 - 2% turmeric powder *	53.60 ± 2.31 (7.38)^{a}	30.07 ± 2.4 (9.94)^{b}	37.07 ± 0.76 (6.17)^{b}	67.64 ± 4.14 (6.11)^{a}	43.8 ± 10.24 (7.38)^{a}
T4 - 2% synthetic vinegar *	56.57 ± 2.44 (7.58)^{a}	47.17 ± 2.10 (7.5)^{a}	46.64 ± 4.42 (6.89)^{a}	59.30 ± 0.82(6.52)^{b}	39.16 ± 5.06(7.58)^{a}
T5 - KAU Veggie wash at 10 ml L^{-1}*	34.88 ± 1.83(7.47)^{b}	33.2 ± 1.86 (8.07)^{b}	9.26 ± 0.75 (3.20)^{e}	37.91 ± 2.65(5.65)^{d}	19.50 ± 7.29(7.47)^{b}
T6 – Simple washing*	5.23 ± 4.12 (2.36)^{e}	12.20 ± 4.30 (12.5)^{c}	34.71 ± 2.67 (5.97)^{b}	18.73 ± 1.07(2.55)^{e}	19.29 ± 8.82(2.36)^{b}
CD(0.05)	(0.997)	(0.573)	(0.587)	(0.363)	(1.473)

Values shown in parentheses are $\sqrt{x+1}$ transformed values. Values are significantly different from each other by LSD at 5 %
*Subjected to dipping in treatment solutions for 5 minutes followed by three normal washings
** Mean of three replications

4.4.2.1.5 Ethion

Treatments *viz.,* dipping fennel in two per cent turmeric solution and two per cent synthetic vinegar solution for five minutes followed by three normal washing in water were on par in their efficacy in removing the residues, to the tune of 43.80 and 39.16 per cent respectively. The losses incurred due to other treatments *viz.,* dipping in two per cent tamarind solution, KAU Veggie wash (10 mL L^{-1}), tap water and two per cent common salt solution for five minutes followed by three washing in tap water were 21.26, 19.50 and 19.29 and 17.66 respectively.

4.4.2.2 Effect of Different Washing Solutions on the Removal of Synthetic Pyrethroid Insecticide Residues

The results of 4.4.2.2 are presented in Table 30

4.4.2.2.1 Bifenthrin

The superior treatment for removing bifenthrin residue from fennel was dipping the seeds for five minutes in two per cent turmeric solution (74.89 per cent) followed by three washing in tap water. Similarly dipping in two per cent synthetic vinegar solution and KAU Veggie wash 10 mL L^{-1} for five minutes reduced 56.16 and 53.93 per cent of residues. The losses incurred due to other treatments were 12.53 per cent (2 per cent tamarind solution) and 17.17 per cent (2 per cent common salt solution). Dipping in tap water (3.64 per cent) was ineffective compared to other treatments.

4.4.2.2.2 Lambda cyhalothrin

The extent of removal of Lambda cyhalothrin residues from fennel through different decontamination treatments was less than 50 per cent. Dipping in the solution of two per cent synthetic vinegar and two per cent turmeric solution for five minutes followed by three washing were the superior treatments, which could remove 41.60 and 36.40 per cent of residues respectively. All other treatments like KAU Veggie wash 10 mL L^{-1}, two per cent salt solution, two per cent tamarind solution and simple washing in tap water reduced only 31.00, 11.45, 9.50 and 6.51 per cent of residues respectively.

4.4.2.2.3 Cypermethrin

The decontamination treatments were less effective in removing the cypermethrin residue load on fennel. Among all decontamination treatments, more than 30 per cent removal was observed only in the treatments like dipping the seeds for five minutes in two per cent synthetic vinegar solution (45.40 per cent) and two per cent turmeric solution (37.41per cent). Other treatments *viz.*, KAU Veggie wash 10 mL L-1, two per cent salt solution, two per cent tamarind solution and simple washing in tap water reduced only 29.93 , 15.60, 9.92 and 8.20 per cent of residues respectively.

4.4.2.2.4 Fenvalerate

The percentage removal of fenvalerate residues from fennel when subjected to different decontamination solutions at one day after spraying showed that dipping in two per cent synthetic vinegar solution and two per cent turmeric solution for five minutes were found to remove 64.33 and 57.33 per cent of residues respectively. It was proved that these treatments were statistically on par. However, dipping in KAU Veggie wash 10 mL L^{-1} (38.08per cent), two per cent common salt solution (16.10 per cent), two per cent tamarind solution (15.73per cent) and simple washing in tap water (7.58 per cent) were less effective compared to other treatments.

Table 30: Extent of removal of residues of synthetic pyrethroid insecticides from fennel after dipping in different solutions

Treatments	Mean per cent removal of insecticides (%)** ± SD			
	Bifenthrin	Lambda-cyhalothrin	Cypermethrin	Fenvalerate
T1 - 2% commercial tamarind paste *	12.53 ± 0.77(3.67)[d]	9.5 ± 1.21(7.20)[c]	9.90 ± 3.2 (3.27)[d]	15.73 ± 3.44(4.07)[c]
T2 - 2% common salt *	17.17 ± 1.34(4.26)[c]	11.45 ± 3.5(6.38)[c]	15.6 ± 2.92 (4.06)[c]	16.10 ± 0.85(4.13)[c]
T3 - 2% turmeric powder*	74.89 ± 0.39(8.71)[a]	36.4 ± 1.2(8.28)[a]	37.41 ± 1.3(6.19)[ab]	57.33 ± 0.75(6.24)[a]
T4 - 2% synthetic vinegar*	56.16 ± 0.32(7.56)[b]	41.6 ± 0.47 (7.76)[a]	45.40 ± 3.05(6.81)[a]	64.33 ± 0.95(8.08)[a]
T5 - KAU Veggie wash at 10 mlL^{-1}*	53.93 ± 0.40(7.41)[b]	31 ± 2.01(6.23)[b]	29.93 ± 4.56(5.55)[b]	38.08 ± 3.30(7.63)[b]
T6 - Simple washing*	3.64 ± 0.85(2.14)[e]	6.51 ± 5.3(4.44)[b]	8.20 ± 2.56(2.98)[d]	7.58 ± 5.68(2.78)[d]
CD(0.05)	(0.771)	(1.130)	(0.688)	(0.974)

Values shown in parentheses are $\sqrt{x+1}$ transformed values. Values are significantly different from each other by LSD at 5 %
*Subjected to dipping in treatment solutions for 5 minutes followed by three normal washings
** Mean of three replications

4.5 EFFECT OF DIFFERENT HOUSEHOLD PRACTICES ON THE REMOVAL OF PESTICIDE RESIDUES FROM GINGER

The efficacy of different solutions of household products in removing residues from peppermint leaves are presented below.

4.5.1 Effect of Different Washing Solutions on the Removal of Organophosphate Insecticide Residues

The results of 4.5.1 are presented in Table 31

4.5.1.1 Dimethoate

The extent of removal of dimethoate residues from ginger when dipped in two per cent tamarind solution and two per cent common salt solution were 45.84 and 42.83 per cent respectively. However, percentage reduction in treatments *viz.,* dipping in two per cent synthetic vinegar solution, KAU Veggie wash 10 mL L^{-1} and tap water were 26.32, 37.71 and 11.22 per cent respectively.

4.5.1.2 Quinalphos

The percentage removal of quinalphos residues in ginger when subjected to different decontamination solutions one day after spraying showed that all the treatments differed significantly among each other. It has been found that dipping in two per cent tamarind solution (45.12 per cent) and two per cent common salt solution (39.33 per cent) were found to be the superior treatments. The percentage removal of residues when dipped in other decontaminating solutions were 37.49 (2 per cent synthetic vinegar), 33.33 (KAU Veggie wash 10 mL L^{-1}) and 8.50 per cent (simple washing in tap water).

4.5.1.3 Chlorpyriphos

All the decontamination treatments differed in their efficacy in removing the chlorpyriphos residues detected in ginger one day after

Table 31: Extent of removal of residues of organophosphate insecticides from ginger after dipping in different solutions

Treatments	Mean per cent removal of insecticides (%)*± SD				
	Dimethoate	Quinalphos	Chlorpyriphos	Profenophos	Ethion
T1 - 2% commercial tamarind paste	45.84±3.34(6.22)^{a}	45.12±5.75(6.79)^{a}	43.83±4.5(6.69)^{a}	40.23±5.14(6.41)^{a}	44.56±1.86(6.74)^{a}
T2 - 2% common salt	42.83±4.08(6.83)^{ab}	39.33±6.3(6.35)^{b}	41.81±2.21(6.53)^{a}	40.78±4.34(6.45)^{a}	30.50±4.51(5.60)^{b}
T3 - 2% synthetic vinegar	26.32±1.87(5.23)^{c}	37.49±7.81(6.20)^{b}	27.01±3.3(5.28)^{bc}	32.17±2.91(5.75)^{b}	43.16±1.96(6.64)^{a}
T4 - KAU Veggie wash at 10 mlL^{-1}	37.71±3.98 (6.61)^{b}	33.33±8.02(5.80)^{c}	35.62±7.41(6.03)^{b}	37.27±1.66(6.18)^{b}	32.49±2.51(6.59)^{b}
T5 - Simple washing	11.22±1.88(3.49)^{d}	8.5±10.71(3.08)^{d}	26.58±5.99(5.23)^{c}	23.14±5.11(4.96)^{c}	12.22±1.39(3.63)^{c}
CD(0.05)	(0.49)	(1.41)	(0.80)	(0.59)	(0.44)

Values shown in parentheses are $\sqrt{x+1}$ transformed values. Values are significantly different from each other by LSD at 5 %
*Subjected to dipping in treatment solutions for 5 minutes followed by three normal washings
** Mean of three replications

spraying. Dipping in two per cent tamarind solution and two per cent common salt solution for five minutes followed by three washing in tap water was significantly superior in the removal of residues, to the tune of 43.83 and 41.80 per cent respectively. Similarly when ginger was dipped in two per cent synthetic vinegar solution and KAU Veggie wash (10 mL L^{-1}) followed by three washing in tap water, residues were removed to the tune of 27.01 and 35.62 per cent respectively. Dipping in tap water alone for five minutes reduced only 26.58 per cent of residues from ginger.

4.5.1.4 Profenophos

Treatments *viz.,* dipping of ginger in two per cent common salt solution and two per cent tamarind solution for five minutes, reduced the initial residue up to 40.78 and 40.23 per cent respectively. This was followed by KAU Veggie wash (10 mL L^{-1}) and two per cent synthetic vinegar, which removed 32.27 and 32.17 per cent of profenophos residues respectively. Where as simple washing in tap water could remove only 23.14 per cent of residues.

4.5.1.5 *Ethion*

In the case of ethion treated rhizomes, dipping for five minutes in two per cent tamarind solution and two per cent synthetic vinegar solution removed 44.56 and 43.16 per cent of residues respectively. Both the treatments were on par in their effect. This was followed by KAU Veggie wash (10 mL L^{-1}) and two per cent synthetic vinegar, which removed 32.49 and 30.50 per cent of the residues respectively. Where as simple washing in tap water could remove only 12.22 per cent of residues.

4.5.2 Effect of Different Washing Solutions on the Removal of Synthetic Pyrethroid Insecticide Residues

The results of 4.5.2 are presented in Table 32

4.5.2.1 Bifenthrin

The percentage removal of bifenthrin residues in ginger was more than 50per cent when dipped in two per cent tamarind solution (64.01 per cent) and two per cent common salt solution (62.72 per cent) for five minutes followed by three washing in tap water. All the other treatments were less effective in the removal of bifenthrin residues. Dipping in KAU Veggie wash (10 mL L^{-1}) for five minutes followed by three washing resulted in only 35.40 per cent removal of residues, where as other treatments like dipping in synthetic vinegar and tap water for five minutes could remove only 28.91 and 24.71 per cent of residues respectively.

4.5.2.2 Lambda cyhalothrin

The percentage removal of Lambda cyhalothrin residues from ginger when subjected to different decontaminating solutions at one day after spraying showed that dipping in two per cent common salt solution, two per cent tamarind solution and KAU Veggie wash 10 mL L^{-1} for five minutes were found to remove 53.61, 53.40 and 48.42 per cent of residues respectively. It was proved that these treatments were statistically on par. However, dipping in two per cent synthetic vinegar solution (37.29 per cent) and tap water (348 per cent) for five minutes were less effective compared to other treatments.

4.5.2.3 Cypermethrin

The decontamination treatments were less effective in removing the cypermethrin residue load on ginger rhizomes. Among all decontamination treatments, dipping for five minutes in two per cent tamarind solution (46.05 per

Table 32: Extent of removal of residues of synthetic pyrethroid insecticides from ginger after dipping in different solutions

Treatments	Mean per cent removal of insecticides (%)* ± SD			
	Bifenthrin	Lambda-cyhalothrin	Cypermethrin	Fenvalerate
T1 - 2% commercial tamarind paste	64.01±2.84 (8.20)^{a}	53.40±3.02 (7.37)^{a}	46.05±4.28 (6.85)^{a}	35.03± 3.01 (5.91)^{a}
T2 - 2% common salt	60.72±7.31(6.36) ^{ab}	53.61±2.81(7.38) ^{a}	35.49 ± 6.89 (6.30)^{ab}	35.45±5.42 (5.02)^{a}
T3 - 2% synthetic vinegar	28.91±0.84(5.42) ^{cd}	37.28±2.01(6.18)^{b}	28.74±12.12 (6.02)^{c}	16.07±10.72 (4.00)^{b}
T4 - KAU Veggie wash at 10 mlL^{-1}	35.40±2.99(5.74)^{bc}	48.42±1.82 (7.02)^{a}	39.29± 8.45 (6.30)^{bc}	15.57±5.52 (3.94)^{b}
T5 – Simple washing	24.71±4.09(6.17) ^{d}	34.29±7.65 (5.91)^{b}	22.50±1.84(4.84) ^{d}	10.60±6.57(3.16)^{b}
CD(0.05)	(0.66)	(0.59)	(1.12)	(1.32)

Values shown in parentheses are $\sqrt{x+1}$ transformed values. Values are significantly different from each other by LSD at 5 %
*Subjected to dipping in treatment solutions for 5 minutes followed by three normal washings
** Mean of three replications

cent)wasthe best. This was followed by dipping in KAU Veggie wash 10 mL L^{-1} (39.29 per cent) for five minutes followed by washing in tap water. Other decontamination treatments like dipping in two per cent salt solution, two per cent synthetic vinegar and tap water for five minutes reduced only 35.49, 28.74 and 22.50 per cent of residues respectively.

4.5.2.4 Fenvalerate

The percentage removal of fenvalerate residues from ginger when subjected to different decontaminating solutions at one day after spraying showed that dipping in two per cent common salt solution and two per cent tamarind solution for five minutes was found to remove 35.45 and 35.03 per cent of fenvalerate residues respectively. It was proved that these treatments were statistically on par. However, dipping in KAU Veggie wash 10 mL L^{-1} (15.57 per cent), synthetic vinegar solution (16.07 per cent) and tap water (10.60 per cent) were less effective compared to all other treatments.

4.5.3 *Effect of Peeling and Processing of Ginger on the Removal of Organophosphate Insecticide Residues*

The results of 4.5.3 are presented in Table 33

4.5.3.1 Dimethoate

All the processing methods differed significantly in their efficiency in removing dimethoate residues from ginger. Peeling followed by washing and cooking for two minutes was found to be the most effective in removing 62.33 per cent of dimethoate residues however peeling followed by washing alone removed up to 50.06 per cent of residues. Similarly processing plus drying of ginger reduced 58.20 per cent of residues. Simple washing without peeling was not effective in the removal of dimethoate residues as the percentage removal was 11.24 per cent.

Table 33: Extent of removal of residues of organophosphate insecticides from ginger after peeling or processing

Treatments	Mean per cent removal of insecticides (%)*± SD				
	Dimethoate	Quinalphos	Chlorpyriphos	Profenophos	Ethion
T1-Simple washing without peeling	11.24 ± 2.23 (3.34)^{c}	8.53 ±1.15(3.08)^{c}	26.58 ± 5.99 (5.23)^{c}	23.81 ± 4.23(4.96)^{c}	12.22 ± 1.39 (3.63)^{c}
T2- Peeling and washing	50.06 ± 1.88 (7.07)^{b}	43.78 ± 8.96 (6.67)^{b}	50.45 ± 4.37 (7.16)^{b}	62.53 ± 1.97(7.97)^{b}	65.99 ± 2.23 (8.18)^{b}
T3- Peeling, washing and cooking for 2 minutes	62.33 ± 4.40 (7.89)^{a}	56.56 ± 6.26(7.57)^{a}	52.83 ± 4.60 (7.33)^{b}	68.88 ± 1.44 (8.35)^{ab}	75.72 ± 1.54 (8.75)^{a}
T4- Dry ginger (Processing and drying)	58.20 ± 0.43 (7.62)^{a}	66.68 ± 4.72 (8.22)^{a}	64.33 ± 4.81 (8.07)^{a}	70.82 ± 3.33 (8.47)^{a}	76.56 ± 0.96 (8.80)^{a}
CD (0.05)	(0.412)	(0.80)	(0.74)	(0.46)	(0.25)

Values shown in parentheses are $\sqrt{x+1}$ transformed values. Values are significantly different from each other by LSD at 5 %
*Subjected to dipping in treatment solutions for 5 minutes followed by three normal washings
** Mean of three replications

4.5.3.2 Quinalphos

Significant reduction in residue was recorded when ginger rhizomes sprayed with quinalphos was subjected to different decontaminating treatments. Processing plus drying of ginger was the promising treatment in decontaminating quinalphos residues (66.68 per cent) and it was closely followed by peeling of rhizomes, washing and cooking for two minutes with 56.56 per cent removal. Peeling followed by washing resulted in 43.78 per cent reduction of residues. However Simple washing without peeling could remove only 8.53 per cent of residues.

4.5.3.3 Chlorpyriphos

Significant reduction in chlorpyriphos residue was recorded when ginger rhizomes were subjected to processing plus drying (64.33 per cent). Peeling of rhizomes, washing and cooking for two minutes and peeling followed by washing alone resulted in 52.83 and 50.45 per cent reduction of residues. Simple washing without peeling (26.58 per cent) was not effective in the removal of dimethoate residues as the percentage removal was less than 30 per cent.

4.5.3.4 Profenophos

Processing plus drying of ginger was found to be the best treatment in removing 70.82 per cent of residues and it was followed by peeling,washing plus cooking of ginger for two minutes with 68.88 per cent. Peeling followed by washing resulted in 62.52 per cent reduction of residues; however simple washing without peeling could remove only 23.81 per cent.

4.5.3.5 Ethion

The extent of removal of ethion residues from ginger was 75.72 per cent when subjected to peeling washing and cooking. Processing plus drying of ginger showed higher reduction of ethion residues, to the tune of 76.56 per cent. However, more or less similar removal was observed in Peeling,washing plus cooking of ginger for two minutes (75.52 per cent). Peeling and washing of ginger facilitated the removal of 65.99 per cent residues whereas washing without peeling reduced only 12.22 per cent of residues.

4.5.4 *Effect of Different Household Practices on the Removal of Synthetic Pyrethroid Insecticide Residues*

The results of 4.5.4 are presented in Table 34

4.5.4.1 Bifenthrin

The per cent removal of bifenthrin residues in ginger was more than 70 per cent in treatments like drying plus processing of ginger (77.20 per cent) and peeling,washing plus cooking of ginger for two minutes (73.80 per cent). Treatments *viz.,* peeling followed by washing and washing without peeling resulted in 61.40 per cent and 28.92 per cent reduction of residues respectively.

4.5.4.2 Lambda cyhalothrin

In the case of Lambda cyhalothrin, highest removal of residue was observed in peeling of ginger followed by washing and cooking for two minutes (60.43 per cent) and processing plus drying of ginger (59.72 per cent). In all other treatments percentage removal was 49.99 per cent in peeling and washing and 34.29 per cent in simple washing without peeling.

Table 34: Extent of removal of residues of organophosphate insecticides from ginger(peeling or processing)

Treatments	Mean per cent removal of insecticides (%)* ± SD			
	Bifenthrin	Lambda-cyhalothrin	Cypermethrin	Fenvalerate
T1-Simple washing without peeling	28.9 ± 0.84 (5.46)[c]	34.29 ± 4.86(5.91)[b]	22.5 ± 1.84(4.84)[b]	17.77 ± 0.81(4.27)[b]
T2- Peeling and washing	61.4 ± 0.83 (7.90)[b]	49.99 ± 5.25(7.13)[b]	76.44 ± 4.60(8.79)[a]	48.15 ± 4.08(7.00)[a]
T3- Peeling, washing and cooking for 2 minutes	73.8 ± 3.96(8.64)[a]	60.43 ± 2.9(7.83)[a]	77.11 ± 1.01(8.83)[a]	56.55 ± 4.51(7.58)[a]
T4- Dry ginger (Processing and drying)	77.2 ± 2.83(8.84)[a]	59.72 ± 1.05(7.79)[a]	79.69 ± 2.17(8.98)[a]	57.31 ± 6.0(7.62)[a]
CD(0.05)	(0.27)	(0.709)	(0.33)	(0.38)

Values shown in parentheses are $\sqrt{x+1}$ transformed values. Values are significantly different from each other by LSD at 5 %
*Subjected to dipping in treatment solutions for 5 minutes followed by three normal washings
** Mean of three replications

4.5.4.3 Cypermethrin

Significant reduction of cypermethrin residue was recorded when ginger rhizomes were subjected to processing plus drying (79.69 per cent), peeling, washing plus cooking for two minutes and peeling followed by washing alone resulted in 77.11 and 76.44 per cent reduction of residues respectively. Simple washing without peeling (22.50 per cent) was not effective in the removal of cypermethrin residues as the percentage removal was less than 30 per cent.

4.5.4.4 Fenvalerate

The extent of removal of fenvalerate residues from ginger was highest in processing plus drying of ginger (57.31per cent), peeling of ginger followed by washing and cooking for 2 minutes (56.55 per cent) and peeling followed by washing alone (48.15 per cent). Simple washing without peeling (17.77 per cent) was not effective in the removal of fenvalerate residue as the percentage removal was less than 30 per cent.

4.6 SENSORY EVALUATION

In this experiment, sensory evaluation of best three decontamination treatments and a water wash (control) was conducted for each spice separately. Best three decontamination treatments of peppermint leaves, coriander leaves, cumin seed and fennel were dipping the leaves in two per cent turmeric solution, two per cent synthetic vinegar and KAU Veggie wash 10 mL L^{-1}. However two per cent tamarind paste, two per cent common salt and KAU Veggie wash 10 mL L^{-1} were the best treatments in ginger. Decontamination treatments evaluated in case of red chilli were removal of fruit stalk and powdering, dipping in KAU Veggie wash (10 mL L^{-1}) and dipping dry chilli fruits in curd and salt.

Table 35:Sensory quality of chutney (Peppermint leaves)

Treatments	Mean rank values				
	Colour and appearance	Flavour	Taste	Texture	Overall acceptability
2% Turmeric powder	17.35 (3.00)	20.50 (4.50)	20.50 (4.00)	20.50 (3.90)	20.50 (4.00)
2% Synthetic vinegar	21.55 (3.50)	20.50 (4.50)	20.50 (4.00)	20.50 (3.90)	20.50 (4.00)
KAU Veggie wash $10mlL^{-1}$	21.55 (3.50)	20.50 (4.50)	20.50 (4.00)	20.50 (3.90)	20.50 (4.00)
Water wash	21.55 (3.50)	20.50 (4.50)	20.50 (4.00)	20.50 (3.90)	20.50 (4.00)
K value	1.07	0	0	0	0

Values in the parentheses are the mean score values

Table 36:Sensory quality of chutney (coriander leaves)

Treatments	Mean of rank				
	Colour and appearance	Flavour	Taste	Texture	Overall acceptability
2% Turmeric powder	13.15 (2.80)	20.50 (4.20)	20.50 (3.90)	20.50 (4.00)	20.5 (3.10)
2% Synthetic vinegar	22.90 (3.80)	20.50 (4.20)	20.50 (3.90)	20.50 (4.00)	20.5 (3.10)
KAU Veggie wash $10 mlL^{-1}$	22.90 (3.80)	20.50 (4.20)	20.50 (3.90)	20.50 (4.00)	20.5 (3.10)
Water wash	22.90 (3.80)	20.50 (4.20)	20.50 (3.90)	20.50 (4.00)	20.5 (3.10)
K value	5.65	0	0	0	0

Values in the parentheses are the mean score values

Table 37:Sensory quality of pickle (Red chilli)

Treatments	Mean of rank				
	Colour and appearance	Flavour	Taste	Texture	Overall acceptability
Removal of fruit stalk and powdering	20.50 (4.30)	20.50 (3.60)	20.50 (3.50)	20.50 (3.60)	20.50 (3.90)
Dipping in KAU Veggie wash (10ml L^{-1})	20.50 (4.30)	20.50 (3.60)	20.50 (3.50)	20.50 (3.60)	20.50 (3.90)
	20.50 (4.30)	20.50 (3.60)	20.50 (3.50)	20.50 (3.60)	20.50 (3.90)
Dipping in tap water	20.50 (4.30)	20.50 (3.60)	20.50 (3.50)	20.50 (3.60)	20.50 (3.90)
K value	0	0	0	0	0

Values in the parentheses are the mean score values

Table 38:Sensory quality of finger chips (Fennel)

Treatments	Mean of ranks				
	Colour and appearance	Taste	Flavour	Texture	Overall acceptability
2% Turmeric powder	5.50(1.00)	5.60 (1.80)	6.90(1.50)	8.50 (2.00)	5.50(3.20)
2% Synthetic vinegar	20.50(2.40)	17.50 (2.90)	19.80(2.4)	20.10 (3.40)	20.50 (4.00)
KAU Veggie wash $10mlL^{-1}$	20.50 (2.40)	17.50 (2.90)	19.80 (2.4)	20.10 (3.40)	20.50 (4.00)
Water wash	20.50 (2.40)	17.50 (2.90)	19.80 (2.4)	20.10 (3.40)	20.50 (4.00)
K value	21.96	20.22	17.04	14.4	21.04

Values in the parentheses are the mean score values

Table :40 Sensory quality of curd with ginger

Treatments	Mean of Ranks				
	Colour and appearance	Flavour	Taste	Texture	Overall acceptability
2% Tamarind paste	20.50 (4.00)	20.50 (2.80)	20.50 (3.70)	20.50 (3.60)	20.50 (4.00)
2% Common salt	20.50 (4.00)	20.50 (2.80)	20.50 (3.70)	20.50 (3.60)	20.50 (4.00)
KAU Veggie wash $10mlL^{-1}$	20.50 (4.00)	20.50 (2.80)	20.50 (3.70)	20.50 (3.60)	20.50 (4.00)
Water wash	20.50 (4.00)	20.50 (2.80)	20.50 (3.70)	20.50 (3.60)	20.50 (4.00)
K value	0	0	0	0	0

Table : 39 Sensory quality of cumin water

Treatments	Mean of ranks				
	Colour and appearance	Taste	Flavour	Texture	Overall acceptability
2% Turmeric powder	7.90 (2.2)	9.25 (1.50)	6.70 (1.1)	5.50 (2.00)	7.60 (3.20)
2% Synthetic vinegar	24.70 (2.20)	24.25 (2.50)	25.10 (2.20)	25.50 (3.20)	24.80 (4.30)
KAU Veggie wash $10mlL^{-1}$	24.70 (2.20)	24.25 (2.50)	25.10 (2.20)	25.50 (3.20)	24.80 (4.30)
Water wash	24.70 (2.20)	24.25 (2.50)	25.10 (2.20)	25.50 (3.20)	24.80 (4.30)
K value	16.01	15.04	25.05	28.67	24.22

Values in the parentheses are the mean score values

Table :40 Sensory quality of curd with ginger

Treatments	Mean of Ranks				
	Colour and appearance	Flavour	Taste	Texture	Overall acceptability
2% Tamarind paste	20.50 (4.00)	20.50 (2.80)	20.50 (3.70)	20.50 (3.60)	20.50 (4.00)
2% Common salt	20.50 (4.00)	20.50 (2.80)	20.50 (3.70)	20.50 (3.60)	20.50 (4.00)
KAU Veggie wash 10mlL^{-1}	20.50 (4.00)	20.50 (2.80)	20.50 (3.70)	20.50 (3.60)	20.50 (4.00)
Water wash	20.50 (4.00)	20.50 (2.80)	20.50 (3.70)	20.50 (3.60)	20.50 (4.00)
K value	0	0	0	0	0

Mean of rank obtained from ten respondents for different parameters like colour and appearance, flavour, taste and over all acceptability is summarised in Table 35 to 40

4.6.1 Sensory Quality of Chutney (Peppermint Leaves)

In the case of colour and appearance, lowest mean rank value was obtained for the chutney prepared from peppermint leaves dipped in turmeric solution (17.35). In all other treatments mean rank value remained the same (21.55) but no significant difference was observed. In case of flavour, taste, texture and overall acceptability, mean rank values were not found to be significantly different (20.50).

4.6.2 Sensory Quality of Chutney (Coriander Leaves)

The results revealed that mean rank value of colour and appearance is less for the chutney prepared from coriander leaves dipped in turmeric solution (13.15) compared to chutney prepared from coriander leaves subjected to other treatment solutions (22.90). In all other parameters like flavour, taste, texture and overall acceptability, mean rank value remains same for all the four treatments (20.50) and were not significantly different.

4.6.3 Sensory Quality of Pickle (Red chilli)

The results show that mean rank value for colour and appearance, flavour, taste, texture and overall acceptability remains same (20.50) for all four samples prepared separately from the chilli powder subjected to three different treatments. There was no significant difference between the treatments

4.6.4 Sensory Quality of Finger Chips (Fennel)

Result indicates that lowest mean rank value for colour and appearance (5.50), flavour (6.90), taste (5.60), texture (8.50) and overall acceptability (5.50) was found in finger chips dipped in turmeric washed fennel powder. This is significantly different from all other treatments where mean rank value remains same for each parameter.

4.6.5 Sensory Quality of Cumin Water

The lowest mean rank values of colour and appearance (7.90), flavour (5.50), taste (9.25), texture (5.50) and overall acceptability (7.60) of cumin water was observed in turmeric treated cumin water compared to cumin water prepared from other treatments. Mean rank value of other three treatments viz., two per cent synthetic vinegar, KAU Veggie wash and washing in tap water remained same for each parameter.

4.6.6 Sensory Quality of Curd (Ginger)

The results shows that no changes in sensory attributes namely colour, appearance, flavour, taste, texture and overall acceptability for curd flavoured with ginger subjected to four different washing treatments, as the mean rank value for all the parameters remained same (20.50) and there was no significant difference.

Discussion

5. DISCUSSION

Indiscriminate and excessive use of insecticide for pest management resulted in heavy load of insecticides on raw agricultural commodities. It is therefore of significance to evaluate simple, cost effective strategies adoptable by consumers to enhance food safety from harmful pesticides. Food processing at domestic level would offer a suitable means to tackle the current scenario of unsafe food (Kaushik *et al.*, 2009). Extensive review of literature demonstrates that several decontamination products *viz.,* common salt, turmeric solution, vinegar etc were effective decontaminating agents for vegetables (Abou Arab,1999., Vijayasree *et al.*, 2013., Nair *et al.*, 2014) whereas the literature related to the decontamination of spices are less. Hence the present study entitled "Mangement of pesticide residues in select spices" was taken up with the objective to standardize different household techniques to remove residues from spices *viz.,* peppermint leaves, coriander leaves, red chilli, cumin, fennel and ginger are discussed below.

5.1 VALIDATION OF MULTI RESIDUE METHODS (MRM) FOR PESTICIDE RESIDUE ANALYSIS IN SPICES

In this study, Multi Residue Methods (MRM) for pesticide residue analysis of peppermint leaves, coriander leaves, red chilli, cumin, fennel and ginger were validated by conducting recovery studies. This was to ensure the reliability for pesticide residue analysis in spices. The results shows that the method followed for each spice commodity had a satisfactory analytical performance in terms of selectivity and linearity within the range of 0.05 to 0.5 mg kg $^{-1}$ for five organophoshate and four synthetic pyrethroid insecticides (Appendix). For all the insecticides evaluated, the mean percentage recovery ranged from 74.75 to 117.33 which were within the internationally accepted mean recovery range of 70 to 120 per cent and the Relative Standard Deviation (RSD) was less than 20 per cent which indicated the repeatability of the recovery results. These results indicated that the method adopted was sufficiently reliable for pesticide residue analysis in spices.

5.2 STANDARDIZATION OF WASHING WITH SOLUTIONS OF HOUSEHOLD PRODUCTS TO REMOVE PESTICIDE RESIDUES FROM LEAFY SPICES

In this experiment, the effect of different household techniques in removing insecticide residues in peppermint leaves and coriander leaves, one day after spraying was studied. The removal of residues was expressed in terms of percentage of residues. The effect of washing solutions of different household products was evaluated by dipping insecticide sprayed leaves in these solutions followed by three washing in tap water.

Based on the percentage removal, it was statistically proved that there is significant difference in the efficacy of different decontamination solutions in removing residues of five organophosphate insecticide (dimethoate, chlorpyriphos, quinalphos, ethion and profenophos) and four synthetic pyrethroid insecticides (bifenthrin, lamda cyhalothrin, cypermethrin and fenvalerate).

In the present investigation when the insecticide applied peppermint leaves were processed in different decontamination solutions, the removal of residue was noticed higher in the treatments where leaves were dipped in two per cent turmeric, two per cent synthetic vinegar and KAU Veggie wash 10 ml L^{-1}which removed 27.74 to 58.42 per cent of organophosphates and 29.34 to 49.20 per cent of synthetic pyrethroids. Among the various organophosphates, the highest percentage removal was observed in ethion with 58.42 per cent and lowest per cent removal was in dimethoate with less than 40 per cent removal (Figure 1) According to Holland *et al.* (1994), the effectiveness of washing on removal of residues depend upon the location of the pesticide residues; whereas the surface residues were responsive to washing and systemic residues present in tissue was less responsive. Ahmed *et al.* (2011) opined that dimethoate being a systemic

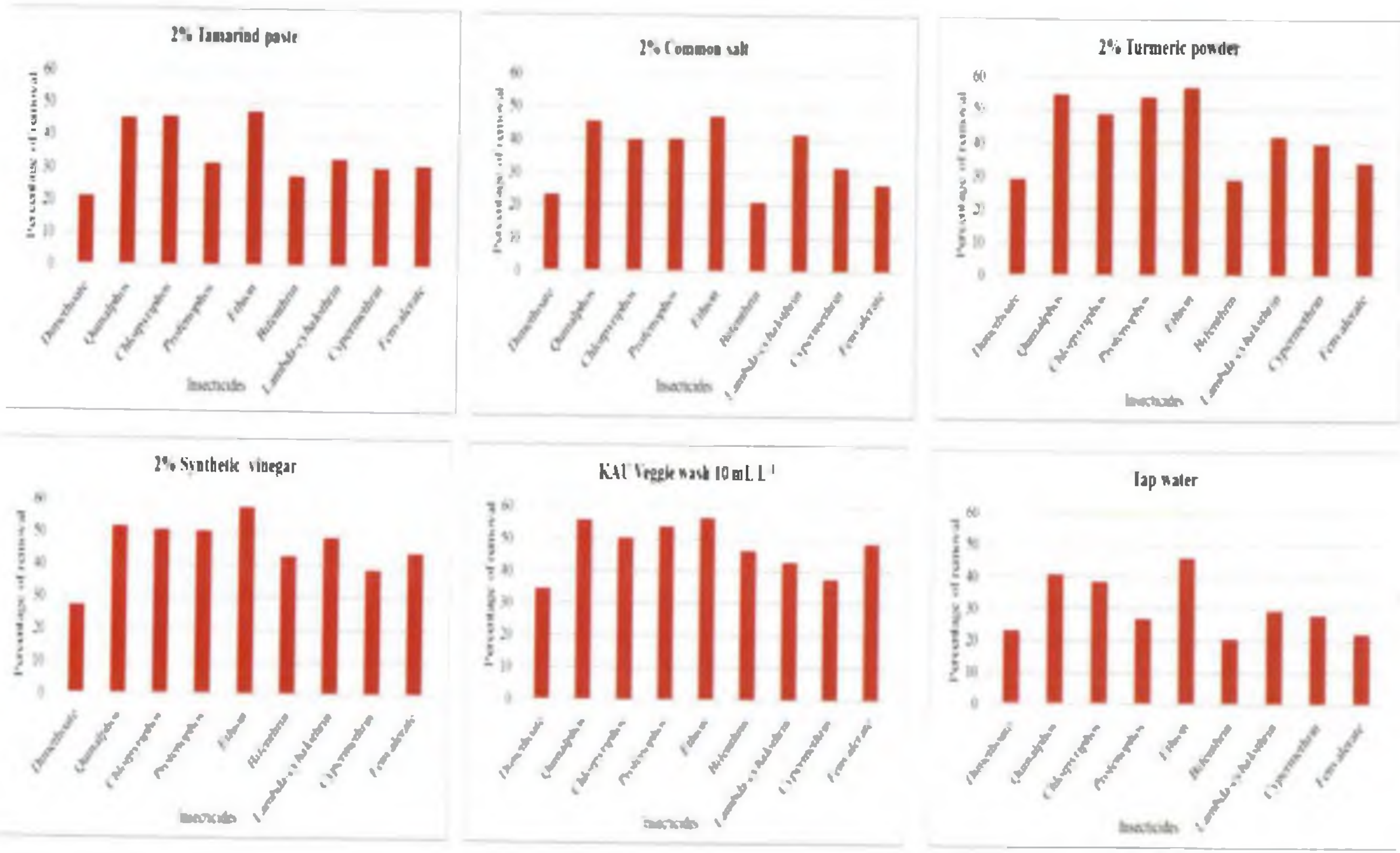

Figure 1. Effect of different washing treatments on the extent of removal of insecticide residues in peppermint leaves

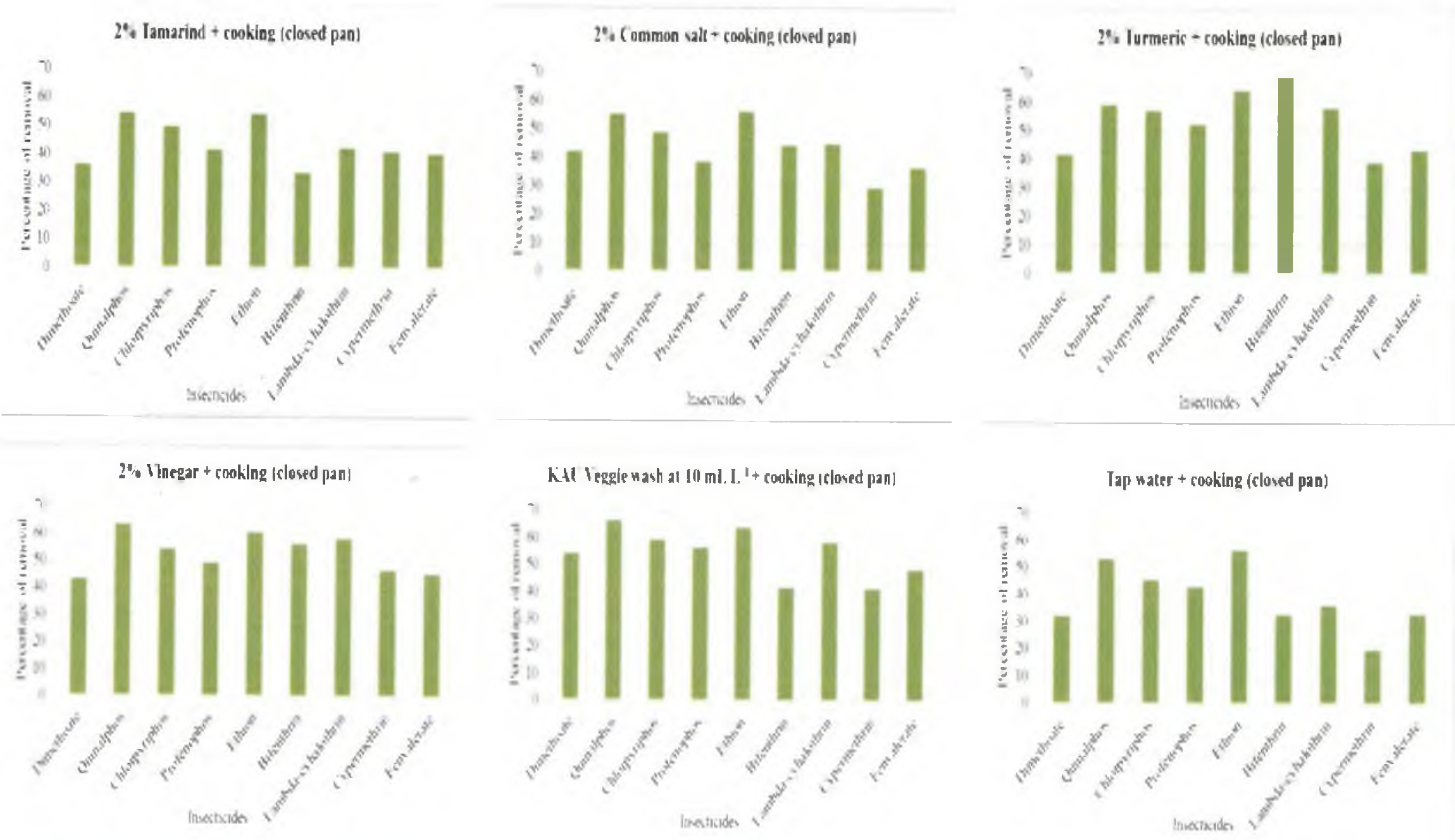

Figure 2. Effect of different washing plus cooking treatments on the extent of removal of insecticide residues in peppermint leaves

insecticide, penetration of residues in to the deeper layers of the commodity prevented its removal.

With regard to the efficacy of the various cooking treatments in removing the insecticide residues from peppermint leaves, dipping in two per cent turmeric, two per cent synthetic vinegar and KAU Veggie wash 10 ml L^{-1} followed by cooking removed more than 60 per cent of residues of quinalphos and ethion where as in other organophosphates (dimethoate, chlorpyriphos and profenophos), the removal ranges were 41.85 to 59.66 per cent and in synthetic pyrethroids removal ranges were 39.3 to 69.23 per cent (Figure 2) This is consistent with the earlier studies which showed that, maximum removal of organophosphate and synthetic pyrethroid residues were noticed in amaranth plants dipped in KAU veggie wash (10 mL L^{-1}) for 20 minutes plus washing and cooking (Muralikrishna. 2015).

A similar trend in the removal of residues was seen in coriander leaves (Figure 3). The residues of most of the insecticides were removed through the treatments *viz.,* two per cent vinegar, two per cent turmeric solution and KAU Veggie wash 10 ml L^{-1}(up to 81.11 per cent), the maximum being for ethion. With regard to cooking treatments, dipping in two per cent synthetic vinegar and KAU Veggie wash 10 ml $L^{-1}$for five minutes followed by cooking in closed pan for ten minutes reduced insecticide deposits to 40 to 80 per cent (Figure 4). Holland *et al.* (1994) reported that volatilization, hydrolysis or other chemical degradation during cooking reduces residue levels. In the present study open pan and close pan cooking of both peppermint and coriander leaves did not show significant variation in the removal of both organophosphate and synthetic pyrethroid insecticides.

Owing to the majority, dipping in two per cent turmeric solution, two per cent synthetic vinegar and KAU Veggie wash 10 ml $L^{-1}$for five minutes followed by three washing in tap water were recommended as good options for removing insecticide residues from peppermint leaves and coriander leaves. These results

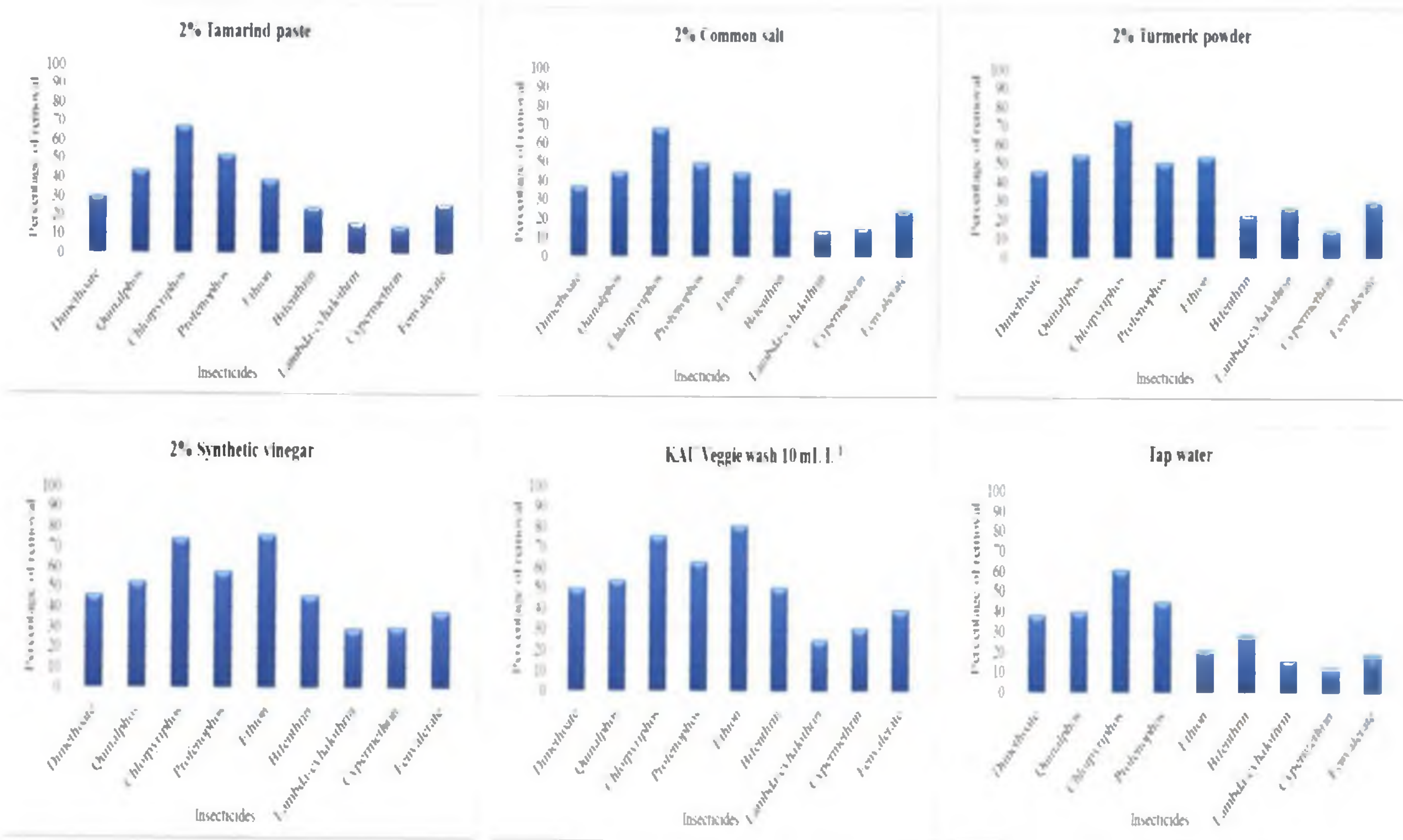

Figure 3. Effect of different washing treatments on the extent of removal of insecticide residues in coriander leaves

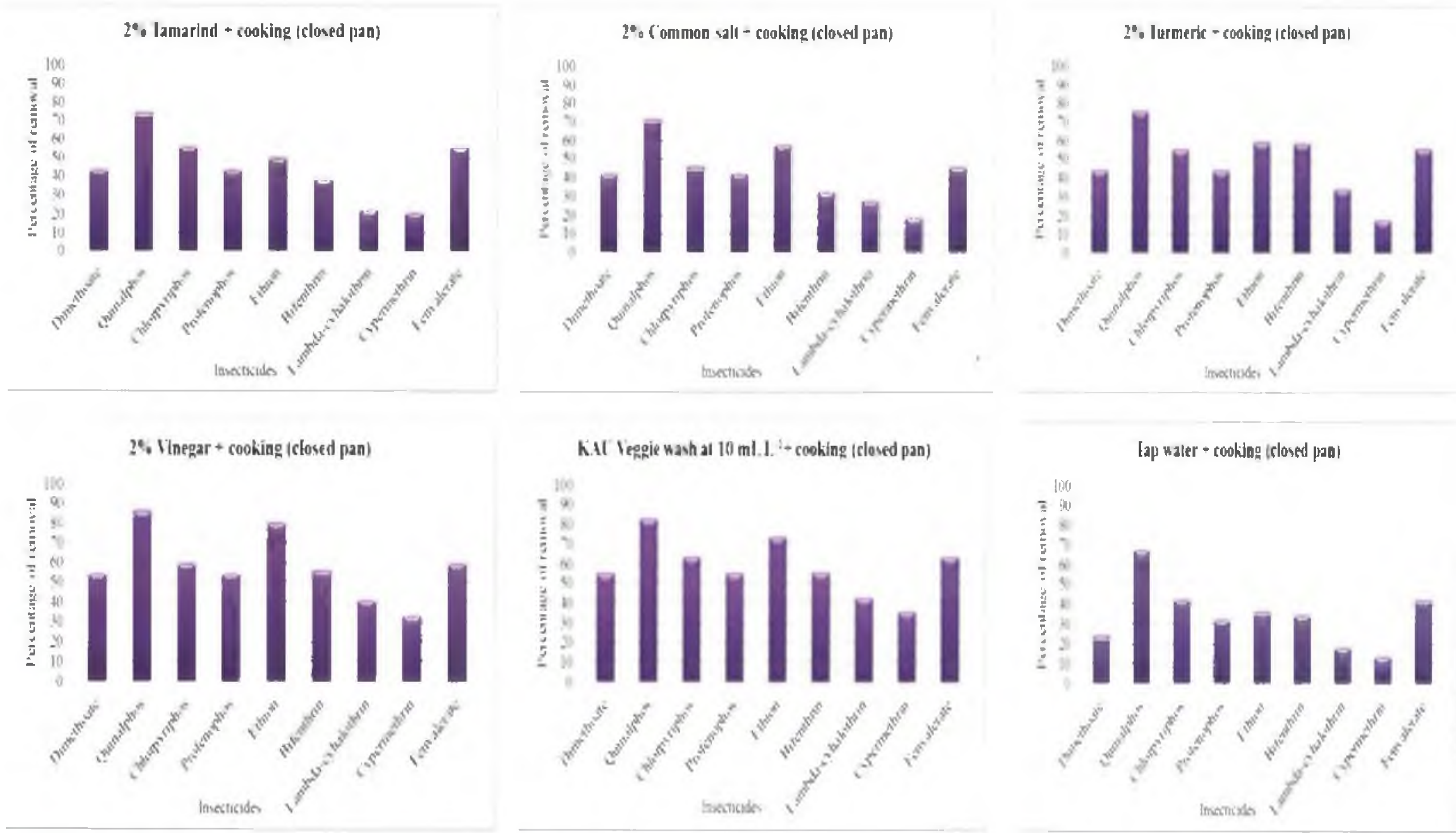

Figure 4. Effect of different washing plus cooking treatments on the extent of removal of insecticide residues in coriander leaves

were in line with the findings of Nair *et al.* (2014), who reported that dipping curry leaves in two per cent vinegar and two per cent turmeric solution for 15 minutes followed by normal washing reduced organophosphorous residues up to 52.77 and 63.89 per cent respectively. Satpathy (2012) reported the significance of pH of solutions in removing residues, two percent vinegar solution is having pH in the range of 2 to 3, and it is clear from the results that the acidity of the vinegar solution is having much significance in the removal of organophosphate and synthetic pyrethroid insecticides. Pesticide molecules have higher affinity to attach with organic materials. Adsorption of pesticide residues to turmeric powder, which is an organic carbonaceous material having lesser particle size and higher surface area may be the reason for the efficiency of turmeric as a decontaminating agent (Nair, 2013).

In the present study, comparatively less per cent removal of insecticide residues was observed in peppermint leaves than in coriander leaves. High persistence of insecticides on the rough surface of the leaves as compared to smooth surface (Min *et al.*, 2006) might be the reason for this difference observed. The corrugated and wrinkled leaves of peppermint having rough surface compared to smooth leaves of coriander, might have helped in higher extent of deposition and retention of insecticides on peppermint leaves.

Comparatively lesser percentage removal was observed in the case of synthetic pyrethroids than organophosphates when subjected to different treatments. This result is not in agreement with that of Bonnechere *et al.* (2012) who reported that low removal is observed in the case of pesticides having high lipophilicity like synthetic pyrethroids, but it agrees with that of Zohair (2001), organophosphorous pesticides were removed more effectively by acidic, neutral and alkaline solutions and the amount of residue removal depended on the concentration and kind of solutions, which further necessitates detailed investigations.

5.3 EFFECT OF DIFFERENT HOUSEHOLD PRACTICES ON THE REMOVAL OF PESTICIDE RESIDUE FROM RED CHILLI (DRY)

A detailed study on the effect of different household processing techniques on the removal of pesticide residues from red chilli was conducted. This study was pertinent in the light of the recent findings that concentration of insecticide residues gets enhanced up to three times by sun drying due to reduction of fresh weight to about one third due to sun drying of red chilli fruits (Xavier *et al.*, 2014). A significant difference between the removal of insecticides belonging to organophosphate and synthetic pyrethroid groups, when subjected to different processing techniques were observed

Dipping of dry chilli in curd and salt was found to be effective on the removal of more than 65 per cent removal of dimethoate, quinalphos and profenophos residues. Almost 64.20 to 75.01 per cent of profenophos and quinalphos residues were removed from fortified dry chilli through the removal of fruit stalk (Figure 5). Kong *et al.* (2012) studied the effect of removing fruit stalk on reduction of pesticide residues in apple and reported that cypermethrin and chlorpyriphos residues concentrated in and around the stalk and cuticular wax served as a barrier in the penetration of these insecticides. The present findings also revealed that non systemic insecticides remains on the surface of fruits and found to be higher in fruit stalk and fruit receptacles. However, removal of seed from dry chilli could remove only less than 20 per cent residues of both organophospate and synthetic pyrethroid insecticides.

Reduction of pesticides in red chilli during sauting and cooking process was studied in detail to estimate the actual concentration of exposure at the final stage of consumption. The present data revealed significant reduction in the levels of pesticides due to cooking chilli powder in water for 20 minutes simulating curry type cooking and sauting dry chilli in frying pan for two minutes (Figure 5). The level of reduction in residues ranged from 22.74 to 85.54 per cent in sauting and

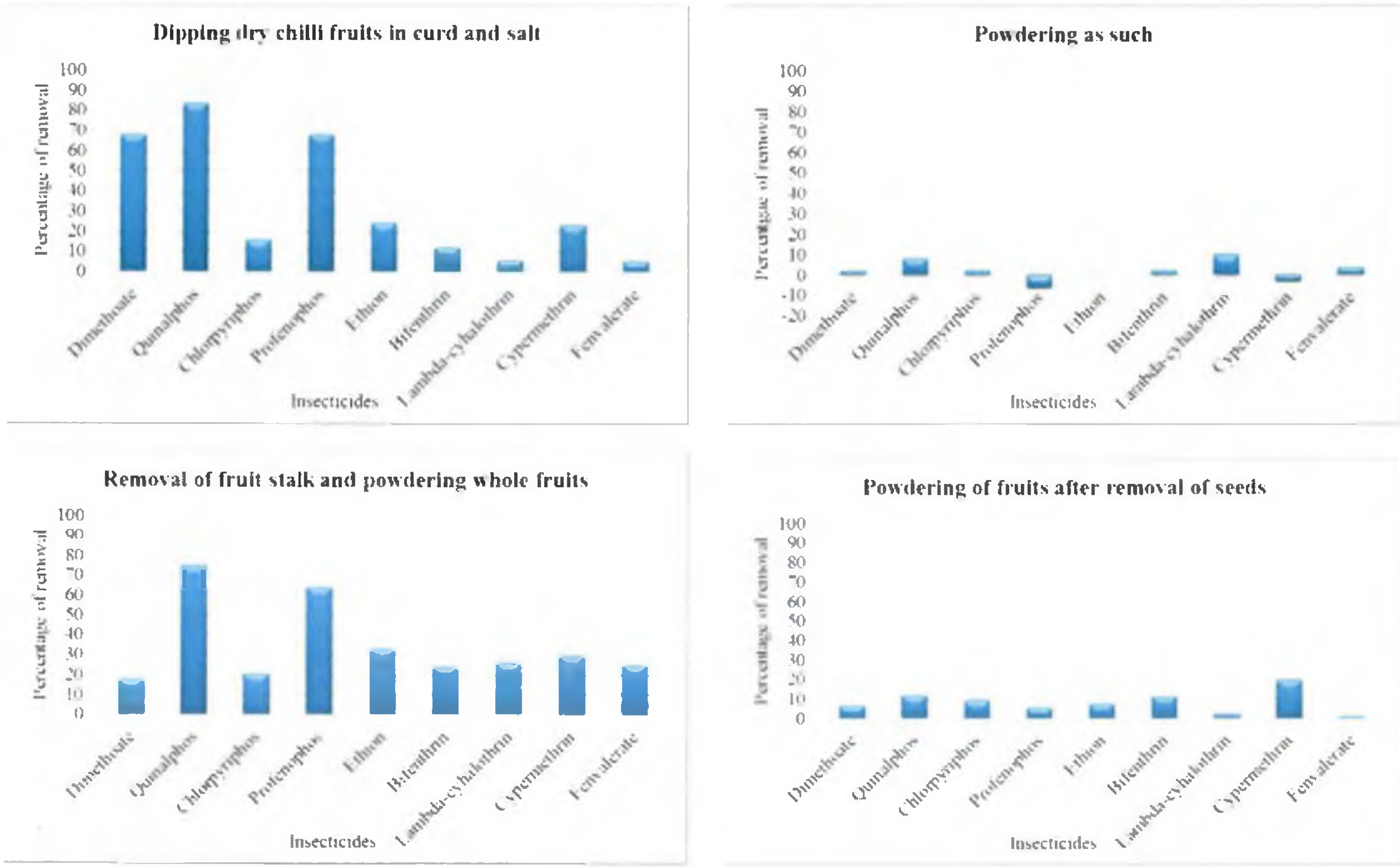

Figure 5. Effect of different treatments on the extent of removal of insecticide residues in red chilli

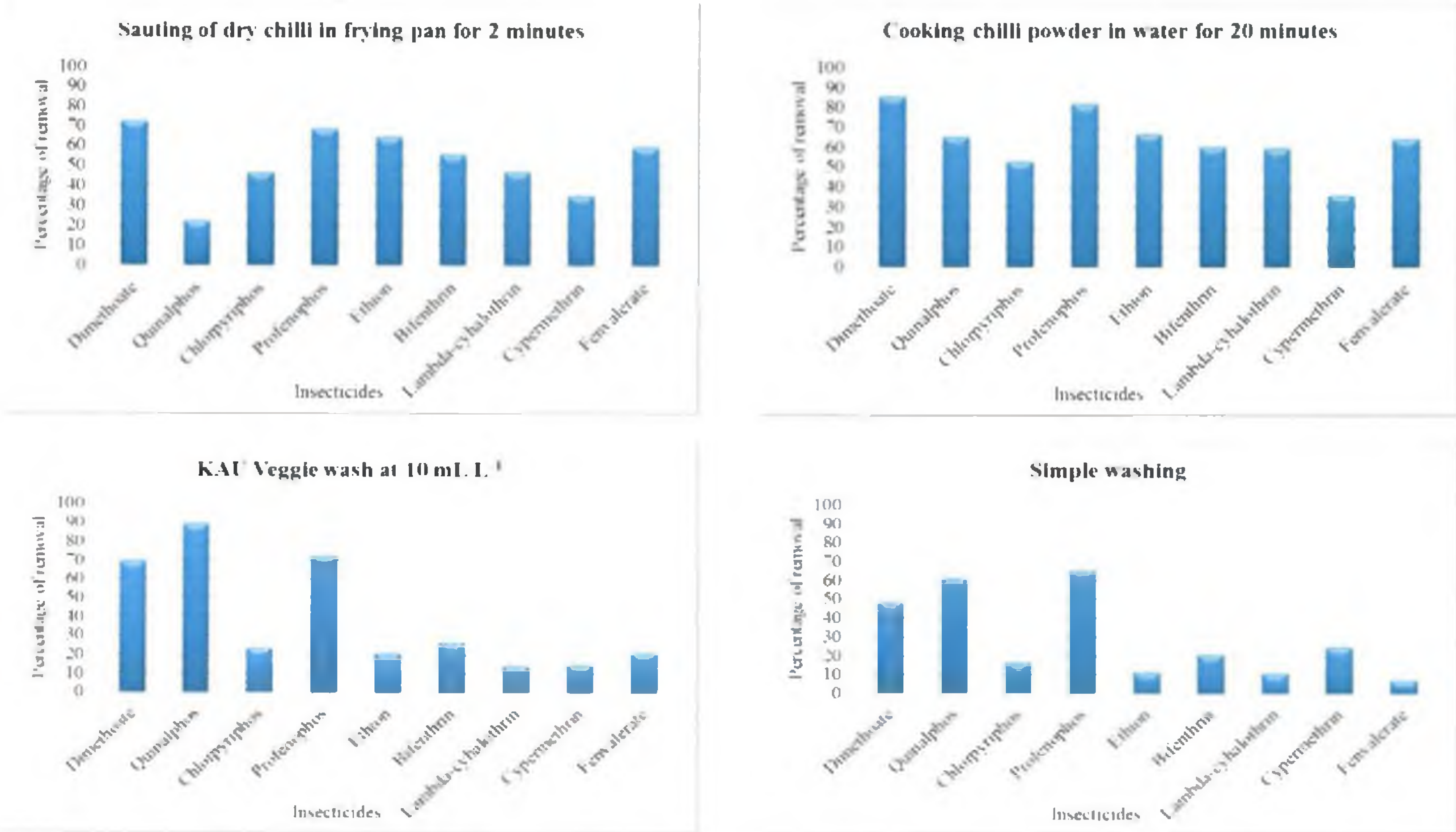

Figure 5. Effect of different treatments on the extent of removal of insecticide residues in red chilli (continued)

from 35.86 to 85.54 per cent in cooking. These findings clearly indicated that heat treatment had a significant effect on decomposition and elimination of pesticide residues. Similar results were also reported by Xavier *et al.* (2014) that cooking of chilli for ten minutes removed 41.81 per cent of monocrotophos and 100 per cent of fenvalerate. The processes that normally occur during cooking is volatilization, hydrolysis and thermal breakdown at elevated temperature, which depends on different parameters, such as vapour pressure, boiling point, and susceptibility of pesticide to hydrolysis (Balinova *et al.*, 2006).

Dipping of chilli fruits in KAU Veggie wash for five minutes followed by three normal washing was found to be very effective in removing orgnophosphate residues *viz.*, dimethoate (69.79 per cent), quinalphos (89.5 per cent) and profenophos (72.30 per cent) and this result is in line with the findings of Muralikrishna (2015) who reported that dipping of amaranthus leaves in KAU Veggie wash removed 61.08 percent dimethoate , 73.75 per cent quinalphos and 73.45 per cent profenophos. However in the case of synthetic pyrethroids, no significant difference between dipping in KAU Veggie wash and in tap water was observed when the per cent reduction of residues was compared.

5.4 EFFECT OF DIFFERENT HOUSEHOLD PRACTICES ON THE REMOVAL OF PESTICIDE RESIDUES FROM CUMIN AND FENNEL

The extent of removal of organophosphate and synthetic pyrethroid insecticides were comparatively less in both cumin seed and fennel (less than 75 per cent). Rough and corrugated surface of seeds might have prevented the dislodging of these residues from seed surface.

Among different organophosphate insecticides evaluated under different types of treatments, highest level of reduction was observed in profenophos (69.50 per cent in cumin seed and 67.64 per cent in fennel) where as dimethoate and chlorpyriphos showed less than 50 per cent removal from both cumin and

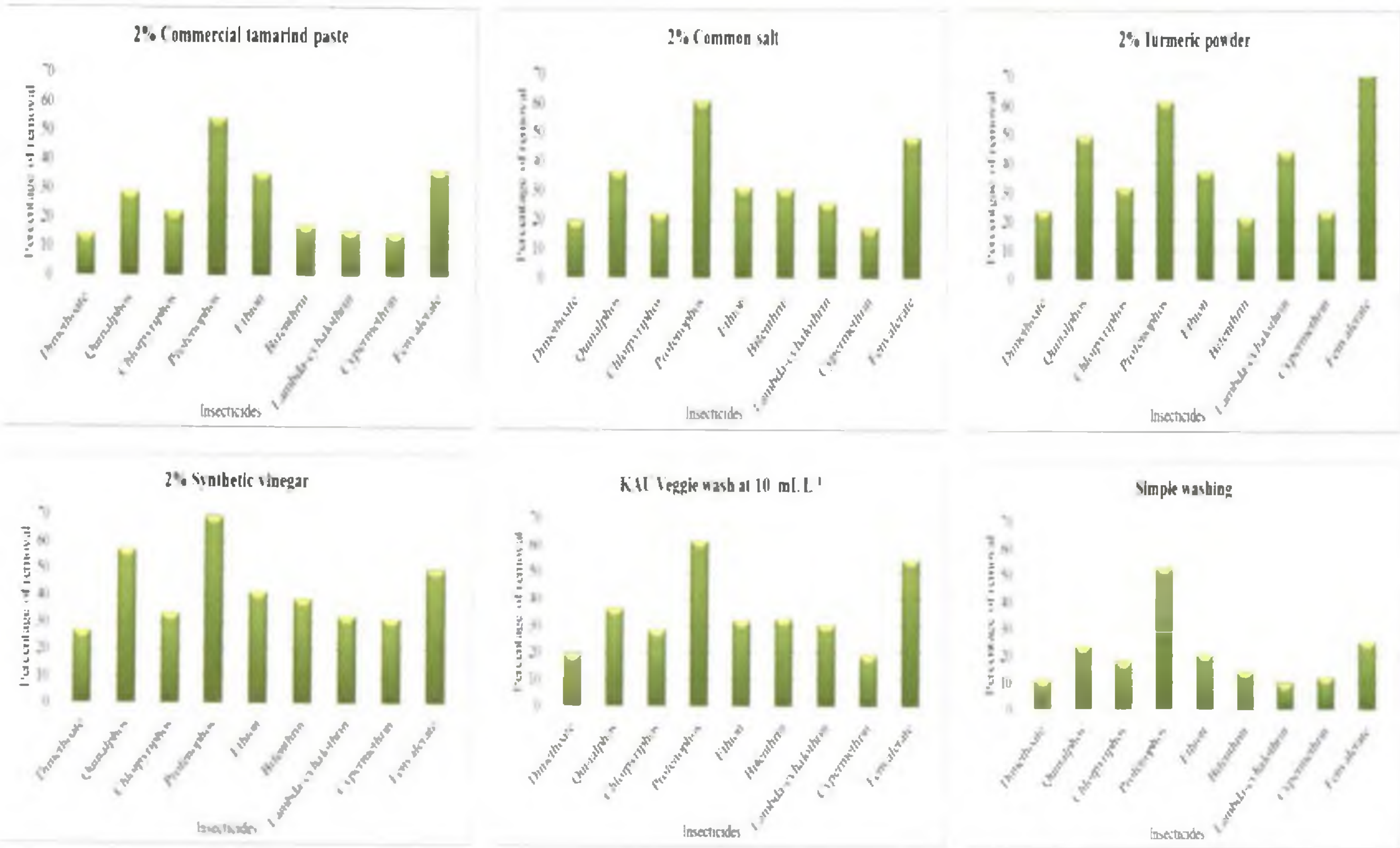

Figure 6. Effect of different washing treatments on the extent of removal of insecticide residues in cumin seeds

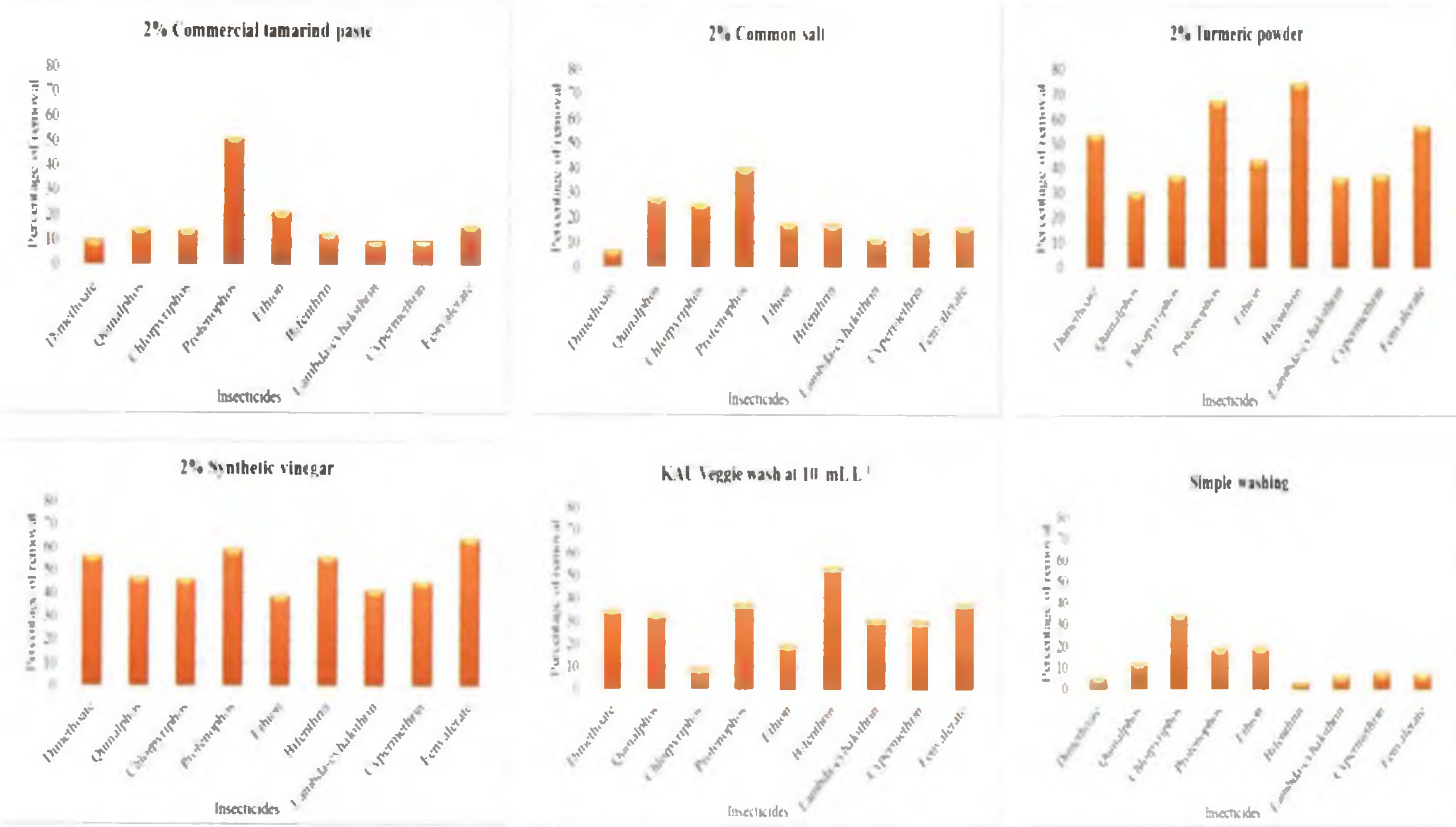

Figure 7. Effect of different washing treatments on the extent of removal of insecticide residues in fennel

fennel seeds (Figure 6 and 7). This is in agreement with that of Vemuri *et al.* (2015) who reported that in the process of washing brinjal under tap water, lowest reduction was reported in chlorpyriphos (35.30 per cent) and dimethoate (30.70 per cent). Similar trend was also observed by Parmar *et al.* (2012) in okra. Comparatively low water solubility of chlorpyriphos (0.0014g L^{-1}) and dimethoate might be the reason for the stability of these insecticides.

In the present investigation when the insecticide applied cumin seeds were processed in different decontamination solutions, the removal of organophosphate residue was noticed higher in dipping in two per cent turmeric and two per cent synthetic vinegar, whereas in case of synthetic pyrethroids, dipping in two per cent synthetic vinegar was effective for bifenthrin and cypermethrin and dipping in two per cent turmeric solution was effective for lambda cyhalothrin and fenvalerate.

With regard to the efficacy of the various washing treatments in fennel, dipping in two per cent turmeric solution was found superior in the reduction of dimethoate, profenophos and ethion residues whereas two per cent synthetic vinegar was effective in removing all organophosphates except profenophos. Both two per cent turmeric solution and two per cent synthetic vinegar was effective in the removal of syntetic pyrethroid residues. Vijayasree *et al.* (2014) reported two per cent turmeric and two per cent synthetic vinegar as effective decontaminating agent in removing residues of emamectin benzoate and spinosad from vegetable cowpea at 0^{th} day and 3^{rd} day after spraying.

KAU Veggie wash was not found to be effective in both cumin and fennel as the percentage removal was only 19.27 to 61.84 per cent in cumin seed and 3.64 to 18.73 per cent in fennel.

When the cumin seed was boiled with water, transfer of insecticide (Organophosphate and synthetic pyrethroid) to the water was less and more residues were retained in the seed fraction

Over all analysis of decontamination of cumin and fennel revealed that dipping in two per cent turmeric solution and two per cent synthetic vinegar were the superior treatments in removing the residues. Study conducted by Wheeler (2002) showed that acidic solutions of 5 and 10 per cent citric and ascorbic acid gave more pesticide dissipation (80 %) than neutral and alkaline solutions.

5.5 EFFECT OF DIFFERENT HOUSEHOLD PRACTICES ON THE REMOVAL OF PESTICIDE RESIDUES FROM GINGER

Results from the study revealed that decontamination treatments including tamarind solution (two per cent) and common salt solution (two per cent) were effective in reducing both organophosphate and synthetic pyrethroid insecticides from ginger rhizomes when compared to other treatment solutions. Amount of residues removed were in the range of 39.33 to 45.80 per cent in common salt solution and 35.03 to 64.01 per cent in tamarind solution (figure 8) and these results were in agreement with the findings of Nair (2013) who reported that dipping capsicum in two per cent salt solution for 15 minutes has removed organophosphate (33.09 to 48.00 per cent) and synthetic pyrethroid residues (53.26 to 54.74 per cent). Similar studies conducted by Varghese (2001) indicated that two per cent tamarind solution was the best decontaminating solution in removing residues of spiromesifen (90.03 per cent) and propargite (96.69 per cent) from green chilli . Pulp of tamarind contains cellulose and lignin, which are carbonaceous material having good adsorbtion efficiency (70 to 90 per cent) (Rasheed, 2013). Thus, it could be inferred that, insecticide residues degraded at low pH and got adsorbed on to mucilage/lignocelluloses fraction of tamarind. As this treatment was found effective for majority of insecticides under the present study, washing with tamarind solution (2 per cent) can be recommended

Among all the insecticides, lowest per cent removal was observed in dimethoate which is systemic in nature. The effectiveness of washing on removal of residues depended upon the location of the pesticide present and that surface

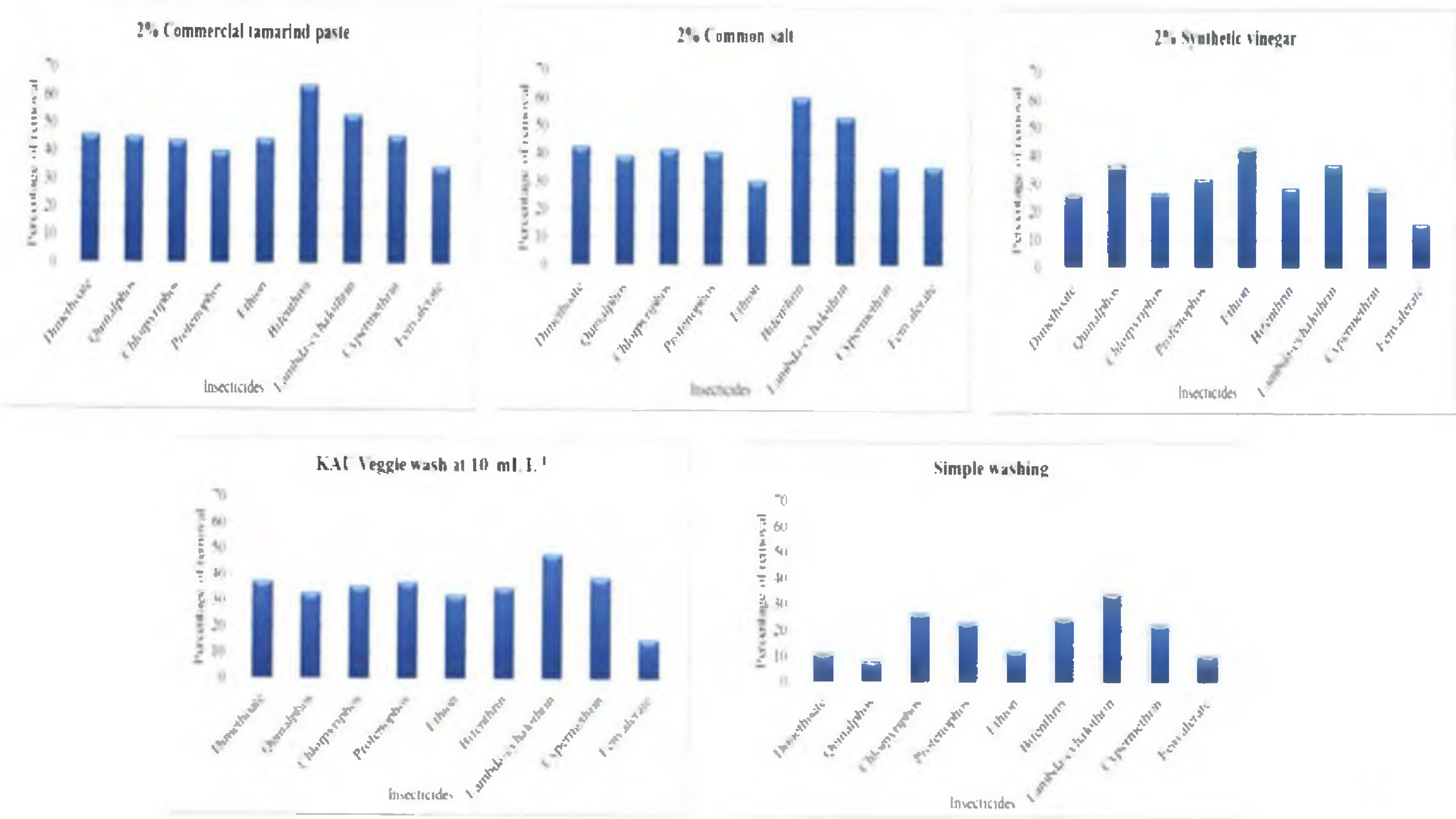

Figure 8. Effect of different washing treatments on the extent of removal of insecticide residues in ginger

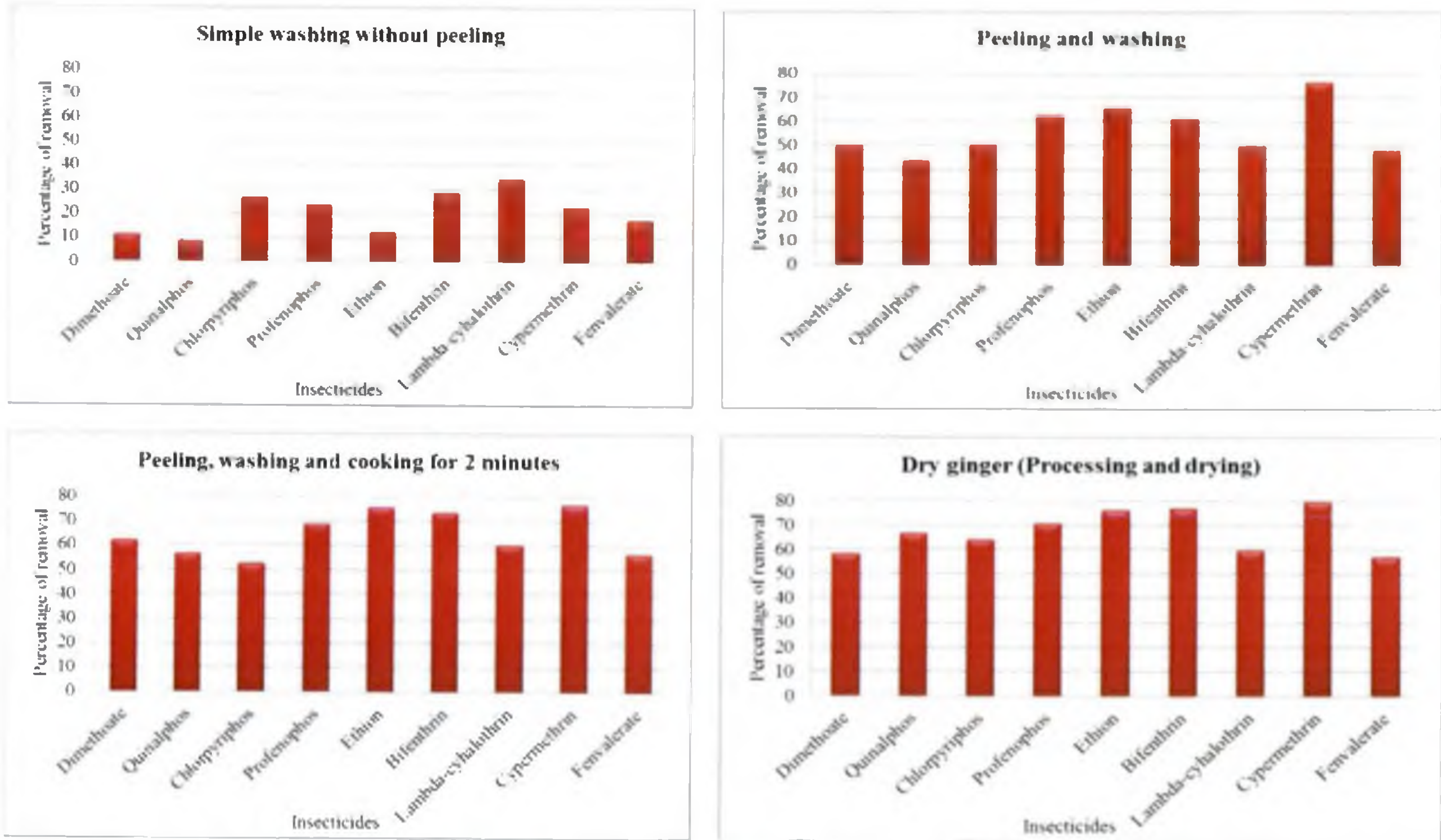

Figure 9. Effect of different treatments (peeling or processing) on the extent of removal of insecticide residues in ginger

residues were responsive to washing unlike systemic residues present in tissues (Holland *et al.*, 1994).

In the case of KAU Veggie wash, amount of residues removed were in the range of 32.27 to 37.70 per cent (organophosphates) and 15.57 to 48.42 per cent (synthetic pyrethroids). Per cent removal was less in ginger where as maximum 90.67 per cent removal was reported in amaranthus (Muralikrishna, 2015).

Peeling process had a significant effect on the removal of both organophosphate and synthetic pyrethroid insecticides from ginger. A majority of insecticides undergo very less movement or penetration and they are confined to outer surface where they are amenable to removal in peeling (Shokrazadeh and Saravi, 2009). Washing and peeling of ginger was found to be effective in removing 43.78 to 65.99 per cent of organophosphate and 48.45 to 76.44 per cent of synthetic pyrethroid insecticides. Similar result was obtained for chlorpyriphos in egg plant and potato with a reduction of 75 per cent and 85 per cent respectively (Randhawa *et al.*, 2007).

Peeling followed by washing and cooking for two minutes was found to be effective in removing 52.83 to 75.72 per cent of organophosphate and 56.55 to 77.11 per cent of synthetic pyrethroid insecticide residues. (Figure 9). These findings were closely related with the findings of Bonnechere *et al.* (2012), who found that pesticide residues were more reduced by washing and peeling.

Thus overall result of the study indicated that, the consumers can reduce the risk of residues in spices by adopting suitable decontamination techniques. In peppermint leaves and coriander leaves, dipping in KAU Veggie wash 10 ml L^{-1}, two per cent synthetic vinegar or two per cent turmeric were the superior treatments in the removal of residues while two per cent synthetic vinegar or two per cent turmeric solution that removed maximum residues were the best decontaminants for cumin seeds and fennel. In the case of ginger, tamarind (two per cent) and common salt (two per cent) were the superior treatments. Among all the decontamination treatments conducted, simple washing followed by cooking was found to be more effective in peppermint leaves, coriander leaves, red chilli and ginger.

5.6 SENSORY EVALUATION

Sensory evaluation conducted to examine the acceptability of best three washing treatments in spices *viz.,* peppermint leaves, coriander leaves, red chilli (dry) cumin seed, fennel and ginger are discussed below.

In peppermint leaves and coriander leaves, washing with different decontamination solutions, *viz.,* two per cent turmeric solution, two per cent synthetic vinegar and KAU Veggie wash 10 ml L^{-1} did not affect the flavour, taste or texture of the chutney. Turmeric solution was the only treatment which gave a lower value for colour and appearance, since the mean rank was non significant, all the three treatments can be accepted. .

In red chilli and ginger, similar mean rank values for all the sensory parameters indicated that, all the three decontamination treatments can be accepted.

Eventhough, percentage reduction of residues was highest when the seeds of cumin and fennel were dipped in two per cent turmeric solution, results of the sensory evaluations showed that the treated were not preferred by the consumers as it affected the colour, taste and flavour of the recipe.

Summary

6. SUMMARY

India is the largest producer and consumer of spices in the world and have been the backbone of agricultural industry in India and earn a major part of foreign exchange annually. Spices have been an integral part of the Indian diet and the household consumption demand for spices is high. However, the major constraint in the production of spices is its proneness to infestation by diverse groups of insects, pests and diseases. Thus among different pest control strategies adopted, pesticide application gives protection from pest and diseases causing considerable reduction in yield loss. The residue of these insecticides on treated surface can reach the consumers during consumption. Different decontamination studies were tried in India and promising results were reported in vegetables, while such decontamination studies are less in spices. With this in view, studies were carried out to standardize household techniques to decontaminate pesticide residues from spices *viz.,* peppermint leaves, coriander leaves, red chilli, cumin seed, fennel and ginger. The results of the studies are summarized here under.

- Studies conducted to assess the effect of washing and cooking on removal of pesticide residues in peppermint leaves revealed that out of the different washing methods adopted, dipping leaves in KAU Veggie wash 10 mL L^{-1}, two per cent synthetic vinegar and two per cent turmeric for five minutes followed by three washings were significantly superior to remove of 27.74 to 58.42 per cent of organophosphates and 29.34 to 49.20 per cent of synthetic pyrethroids. Among various organophosphates, the highest percentage removal was observed in ethion with 58.42 per cent and lowest per cent removal was in dimethoate with less than 40 per cent removal. With regard to the efficacy of the various cooking treatments in removing the insecticide residues from peppermint leaves, dipping in two per cent turmeric, two per cent synthetic vinegar and KAU Veggie wash 10 mL L^{-1} followed by cooking for ten minutes in closed pan removed more than 60 per cent of residues of quinalphos and ethion. Whereas in the case of other organophosphates (dimethoate, chlorpyriphos and profenophos), the removal ranged from 41.85

to 59.66 per cent and in synthetic pyrethroids removal ranged from 39.30 to 69.23 per cent.

- Among the different decontamination techniques adopted in coriander leaves, dipping in KAU Veggie wash 10 mL L^{-1}, two per cent synthetic vinegar and two per cent turmeric for five minutes followed by three washings were found to be effective in removing 45.98 to 81.11 per cent of organophosphates and 14.80 to 50.95 per cent of synthetic pyrethroids. Washing with these solutions and then cooking for 10 minutes also indicated a similar trend in the insecticide removal, the extent of removal being 36.10 to 80.05 per cent and 33.17 to 80.32 per cent in KAU Veggie wash 10 mL L^{-1} and two per cent synthetic vinegar respectively.
- Open pan and close pan cooking of both peppermint and coriander leaves did not show significant variation in the removal of both organophosphate and synthetic pyrethroid insecticides. Comparatively lesser percentage removal was observed in the case of synthetic pyrethroids than organophosphates when subjected to different treatments.
- Dipping of dry chilli in curd and salt was found to be effective in the removal of more than 65 per cent of dimethoate, quinalphos and profenophos residues. Reduction in the residues due to sauting in frying pan for two minutes was 22.74 to 85.54 per cent while cooking chilli powder in water for 20 minutes removed 35.86 to 85.54 per cent residues. Almost 64.20 to 75.01 per cent of profenophos and quinalphos residues were removed from fortified dry chilli through the removal of fruit stalk whereas removal of chilli seeds, drying and powdering resulted in a reduction of only 2.62 to 16 per cent reduction. Dipping of chilli fruits in KAU Veggie wash for five minutes followed by three normal washing was found to be effective in removing orgnophosphates like dimethoate (69.79 per cent), quinalphos (89.5 per cent) and profenophos (72.30 per cent).
- In the case of cumin seed and fennel, dipping in two per cent synthetic vinegar or two per cent turmeric solution for five minutes followed by three normal washing in tap water was found to be superior in removing organophosphate

and synthetic pyrethroid residues. KAU Veggie wash was ineffective in both cumin and fennel as the percentage removal was only 19.27 to 61.84 per cent in cumin seed and 3.64 to 18.73 per cent in fennel.

- When the cumin seed was boiled in water (jeera water) transfer of insecticide residues (organophosphate and synthetic pyrethroid) to water was negligible and the major fractions of residues were retained in the seeds.
- The extent of removal of residues from ginger was significant when treated with tamarind (two per cent) and common salt (two per cent) and it recorded 39.33 to 45.80 per cent and 35.03 to 64.01 per cent removal respectively. In the case of KAU Veggie wash, amount of residues removed were in the range of 32.27 to 37.70 per cent for organophosphates and 15.57 to 48.42 per cent for synthetic pyrethroids.
- Washing and peeling of ginger was found to be effective in removing 43.78 to 65.99 percent of organophosphate and 48.45 to 76.44 per cent of synthetic pyrethroid residues whereas peeling followed by washing and cooking for two minutes removed 52.83 to 75.72 per cent of organophosphate and 56.55 to 77.11 per cent synthetic pyrethroid residues.
- Sensory evaluation of spices on the acceptability of best washing treatments showed that these treatments had no effect on sensory parameters of tested spices except two per cent turmeric in cumin and fennel.
- Overall analysis of the efficacy of decontaminating techniques indicated that dipping in KAU Veggie wash 10 mL L^{-1}, two per cent synthetic vinegar and two per cent turmeric were found to be the best treatments for insecticide treated peppermint leaves and coriander leaves. Two per cent synthetic vinegar and two per cent turmeric solution recorded maximum removal in cumin seeds and fennel. In the case of ginger, tamarind (two per cent) and common salt (two per cent) were the superior treatments. Among all the decontamination treatments conducted, simple washing followed by cooking was found to be more effective in peppermint leaves, coriander leaves, red chilli and ginger.

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MANAGEMENT OF PESTICIDE RESIDUES IN SELECT SPICES

by

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Abstract of the thesis
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COLLEGE OF AGRICULTURE
VELLAYANI, THIRUVANANTHAPURAM-695522
KERALA, INDIA

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ABSTRACT

The present study entitled "Management of pesticide residues in select spices" was carried out at Department of Agricultural Entomology, College of Agriculture, Vellayani during 2014-16. The main objective of the work was to standardize household techniques to decontaminate pesticide residues in select spices.

Investigation was conducted to evaluate the efficacy of different decontamination techniques in removing pesticide residues of organophosphate and synthetic pyrethroid from six select spices *viz.,* peppermint leaves, coriander leaves, red chilli (dry), cumin, fennel and ginger.

Among the different decontamination methods adopted in peppermint, dipping leaves in KAU Veggie wash 10 ml L^{-1}, 2 per cent synthetic vinegar and 2 per cent turmeric for five minutes were significantly superior in the removal of organophosphate and synthetic pyrethroid insecticides, to the tune of 34.8 to 57.30, 27.74 to 58.42 and 29.19 to 54.80 per cent respectively. In the case of coriander leaves, the same treatments were found to be effective in removing up to 81.11 per cent, 76.56 per cent and 72.81 per cent residues respectively. Washing with these solutions and then cooking for 10 minutes also indicated a similar trend in the insecticide removal.

Open pan and close pan cooking of both peppermint and coriander leaves did not show significant variation in the removal of both organophosphate and synthetic pyrethroid insecticides. Comparatively lesser percentage removal was observed in the case of synthetic pyrethroids than organophosphates when subjected to different treatments.

In dry chilli, the reduction in the residues due to sauting in frying pan for two minutes was 22.74 to 72.59 per cent. Cooking chilli powder in water for 20 minutes removed 39.33 to 85.54 per cent residues. Removal of fruit stalk, drying and powdering removed 17.73 to 74.20 per cent whereas removal of chilli seeds, drying and powdering resulted in only 2.62 to 16.00 per cent reduction in residues. Soaking dry chilli in KAU Veggie wash (10 ml L^{-1}) for five minutes was found to be effective in removing 14.51 to 89.50 per cent of the residues.

Dipping cumin and fennel in 2 per cent synthetic vinegar or 2 per cent turmeric for five minutes effectively removed insecticides up to 60 per cent. Cumin seeds and water when tested separately after boiling showed that pesticide concentration was more in cumin seeds (27.50 to 84.60 per cent) compared to that in water (9.05 to 74.30 per cent).

Dipping ginger in 2 per cent tamarind (prepared from commercial tamarind paste) or 2 per cent common salt for five minutes removed insecticides up to 45.08 per cent and 53.60 per cent respectively. Peeling of ginger, cooking or processing (dry ginger) was effective in removing 48.15 to 65.99, 52.83 to 77.11 and 57.31 to 77.20 per cent of the residues respectively.

Organoleptic test conducted showed that washing with different decontamination solutions does not affect the taste and over all acceptability of the select spices evaluated except cumin and fennel dipped in 2 per cent turmeric.

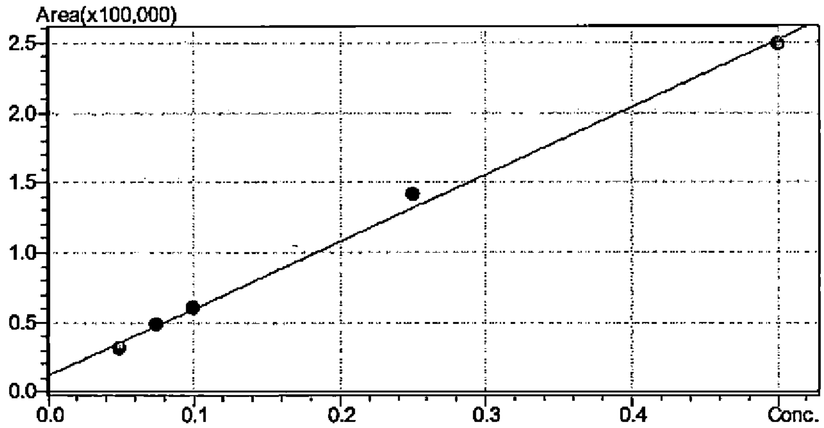
It is concluded that, household techniques to decontaminate pesticide residues in select spices showed that dipping of spices *viz.*, red chilli, coriander leaves, peppermint leaves in KAU Veggie wash (10 ml L^{-1}) for five minutes effectively removed residues of organophosphate and synthetic pyrethroid insecticides to the extent of 14.51 to 89.50, 25.40 to 81.11 and 34.8 to 57.30 per cent respectively. However, KAU Veggie wash was not effective in decontaminating cumin seed, fennel and ginger.

In case of peppermint leaves, dipping in two per cent synthetic vinegar and two per cent turmeric for five minutes followed by three washings were found to be effective in the removal of 27.74 to 58.42 per cent of organophosphates and 29.34 to 49.20 per cent of synthetic pyrethroids. Dipping coriander leaves in two per cent synthetic vinegar and two per cent turmeric for five minutes followed by three washings were found to be effective in removing 45.98 to 81.11 per cent of organophosphates and 14.80 to 50.95 per cent of synthetic pyrethroids.

Dipping in 2 per cent synthetic vinegar or 2 per cent turmeric solution was the most effective treatments in decontaminating cumin and fennel whereas in ginger, dipping in 2 per cent tamarind or 2 per cent common salt removed 35.03 to 64.30 per cent and 25.45 to 53.60 per cent residues respectively.

Appendices

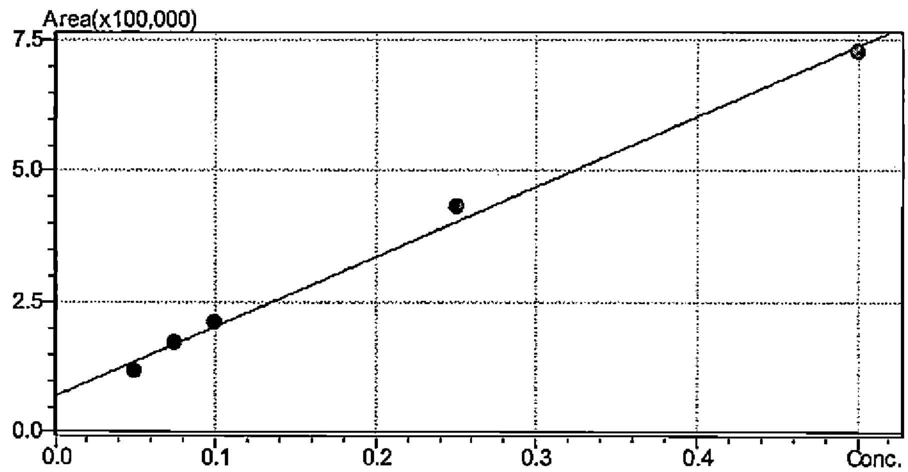
APPENDIX-I



Y = aX + b, a = 479357.6, b = 12224.26, R^2 = 0.9962597, R = 0.9981281

Mean RF: 585280.0, RF SD: 54831.08, RF %RSD : 9.368349

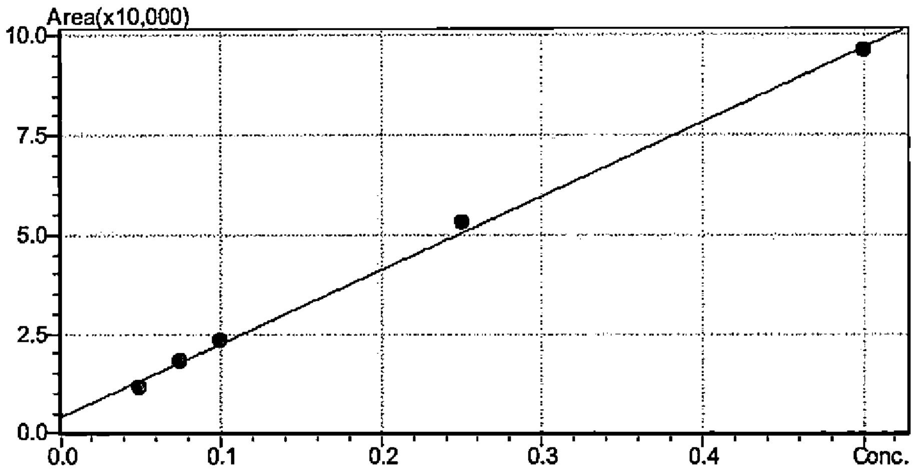
Calibration curve of dimethoate



Y = aX + b, a = 1332620, b = 71327.2, R^2 = 0.9946988, R = 0.9973459

Mean RF : 1982831, RF SD : 362144.3, RF %RSD : 18.26400

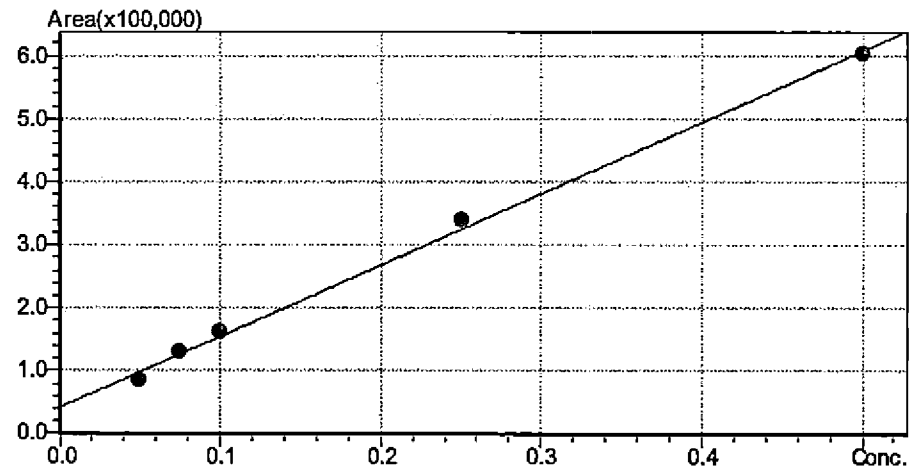
Calibration curve of chlorpyriphos



Y = aX + b, a = 185571.9, b = 4167.843, R^2 = 0.9980365, R = 0.9990178

Mean RF : 222255.5, RF SD : 19244.89, RF %RSD : 8.658903

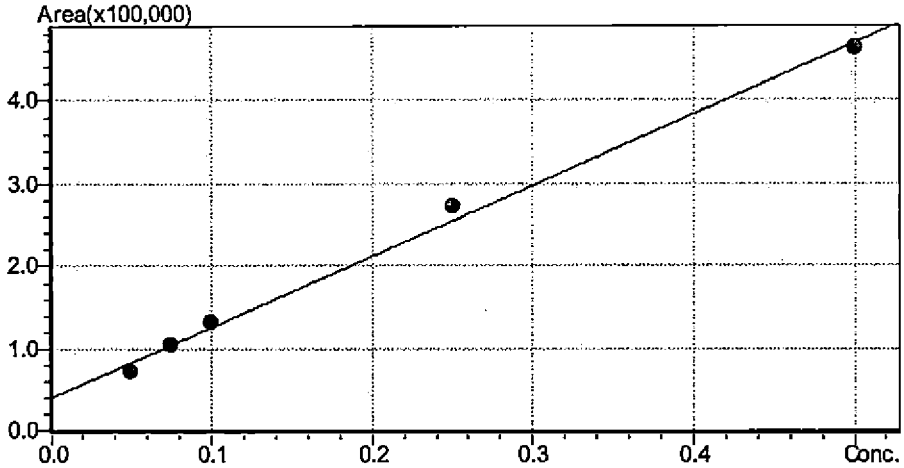
Calibration curve of quinalphos



Y = aX + b, a = 1130056, b = 42623.25, R^2 = 0.9975202, R = 0.9987593

Mean RF : 1518733, RF SD : 221534.9, RF %RSD : 14.58682

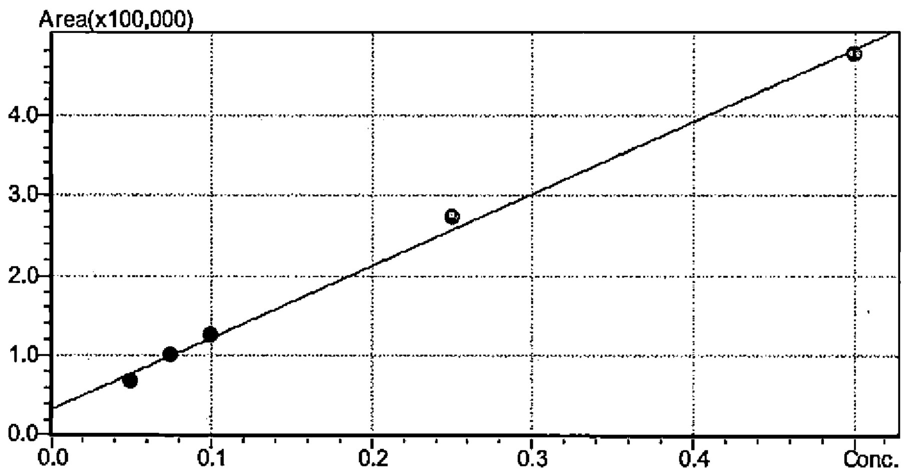
Calibration curve of profenophos



Y = aX + b, a = 856883.4, b = 41325.56, R^2 = 0.9949650, R = 0.9974793

Mean RF : 1231672, RF SD : 206077.7, RF %RSD : 16.73153

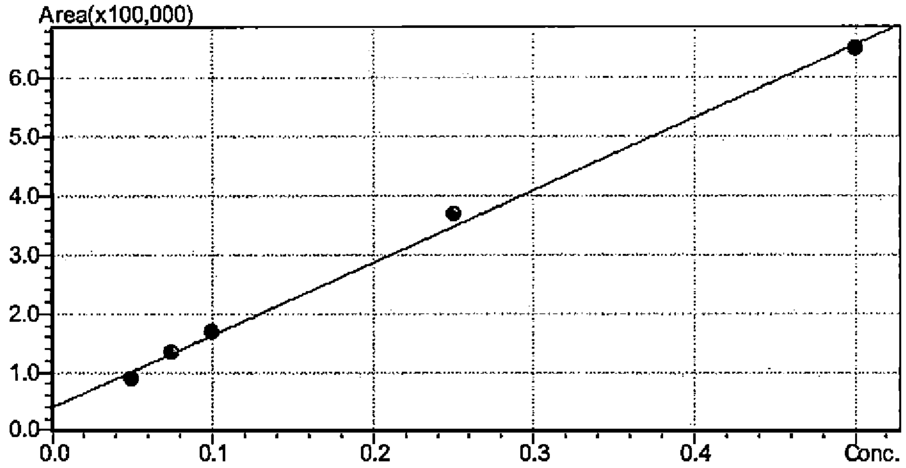
Calibration curve of ethion



Y = aX + b, a = 898096.2, b = 33188.26, R^2 = 0.9960596, R = 0.9980278

Mean RF : 1195523, RF SD : 159444.9, RF %RSD : 13.33684

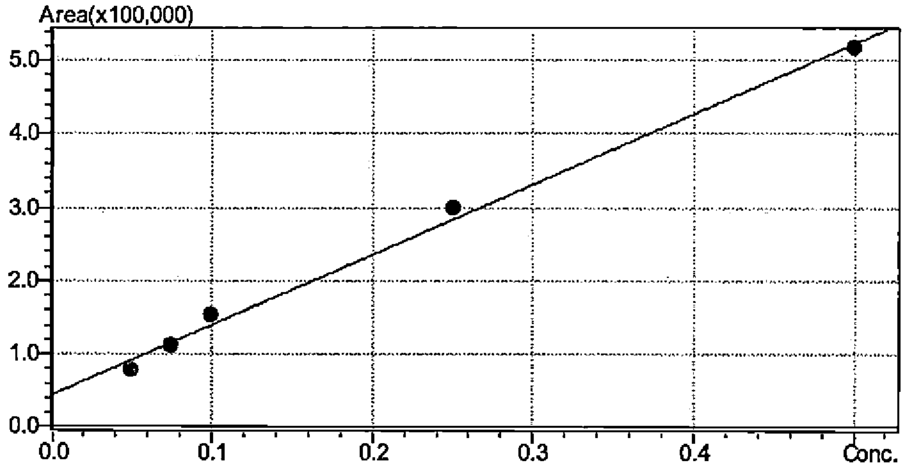
Calibration curve of bifenthrin



Y = aX + b, a = 1233170, b = 40603.28, R^2 = 0.9969946, R = 0.9984962

Mean RF : 1597709, RF SD : 196835.6, RF %RSD : 12.31986

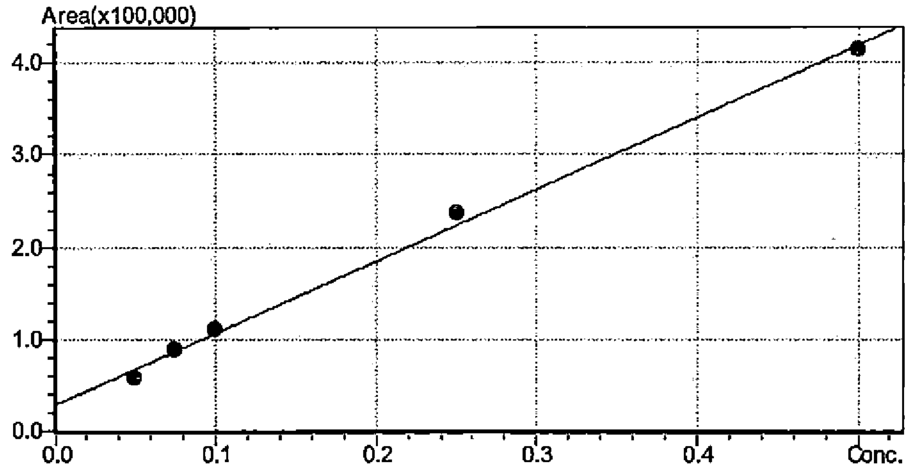
Calibration curve of lambda cyhalothrin



Y = aX + b, a = 955605.3, b = 45446.28, R^2 = 0.9951400, R = 0.9975670

Mean RF : 1367863, RF SD : 229484.3, RF %RSD : 16.77685

Calibration curve of cypermethrin

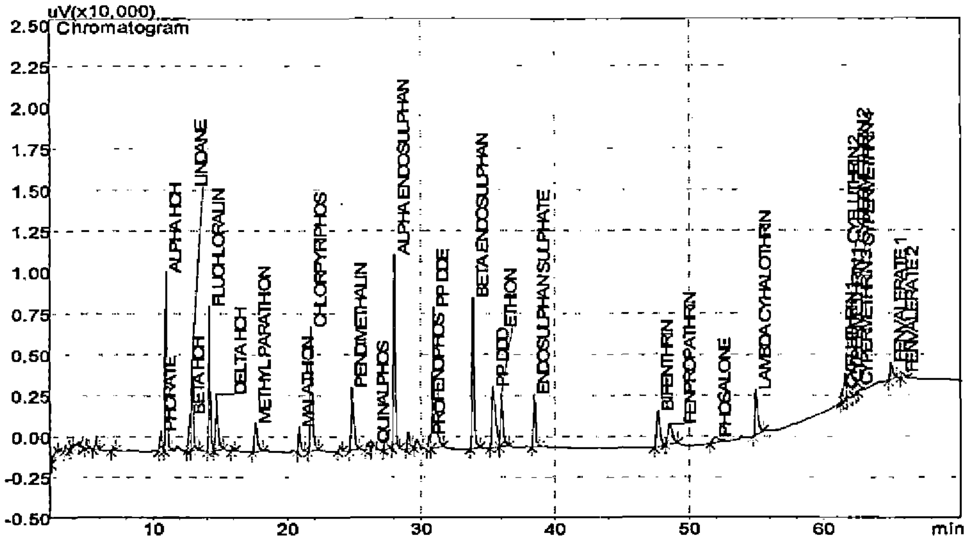


Y = aX + b, a = 777208.5, b = 29941.05, R^2 = 0.9965494, R = 0.9982732

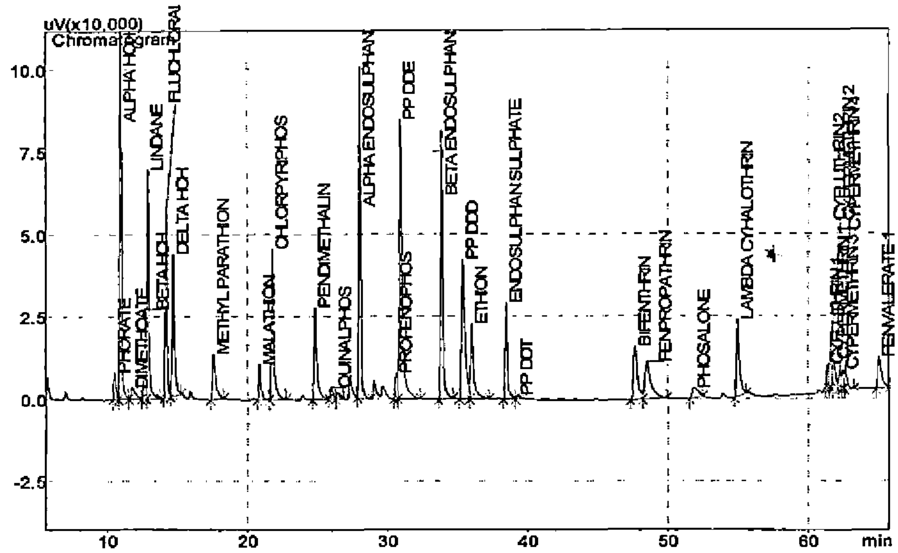
Mean RF : 1047884, RF SD : 148225.5, RF %RSD : 14.14523

Calibration curve of fenvalerate

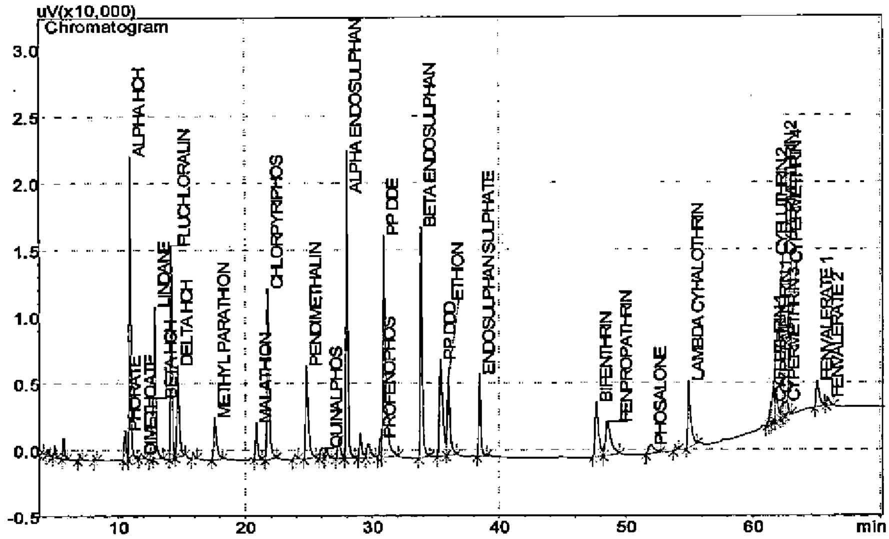
APPENDIX-II



ID#	Name	Ret. Time	Conc.	Units	Peak#	Area	Height
1	PHORATE	10.559	0.05149	ppm	9	12286	1231
2	ALPHA HCH	10.971	0.05020	ppm	10	97489	10847
4	BETA HCH	12.704	0.05043	ppm	11	20399	2222
5	LINDANE	12.892	0.05048	ppm	12	54421	5543
6	FLUCHLORALIN	14.199	0.05102	ppm	13	76226	8817
7	DELTA HCH	14.697	0.05166	ppm	14	43436	3415
8	METHYL PARATHION	17.613	0.04969	ppm	16	26028	1772
9	MALATHION	20.889	0.05089	ppm	17	15226	1536
10	CHLORPYRIPHOS	21.794	0.04963	ppm	18	84391	7565
11	PENDIMETHALIN	24.838	0.05015	ppm	20	51957	3833
12	QUINALPHOS	26.013	0.04423	ppm	21	5236	420
13	ALPHA ENDOSULPHAN	28.033	0.04962	ppm	24	112580	11800
14	PROFENOPHOS	30.655	0.04935	ppm	27	8969	870
15	PP DDE	30.932	0.04980	ppm	28	123629	8592
16	BETA ENDOSULPHAN	33.886	0.05103	ppm	29	94645	9194
17	PP DDD	35.386	0.05106	ppm	30	69028	3721
18	ETHION	36.008	0.04934	ppm	31	43152	3196
19	ENDOSULPHAN SULPHATE	38.459	0.04950	ppm	32	33506	3195
21	BIFENTHRIN	47.702	0.04774	ppm	33	38161	2192
22	FENPROPATHRIN	48.558	0.04540	ppm	34	27519	1251
23	PHOSALONE	51.988	0.04707	ppm	35	10256	348
24	LAMBDA CYHALOTHRIN	54.980	0.04992	ppm	36	38541	2752
25	CYFLUTHRIN 1	61.413	0.04762	ppm	37	6936	823
26	CYFLUTHRIN 2	61.591	0.04612	ppm	38	13916	1209
27	CYPERMETHRIN 1	61.850	0.04397	ppm	39	14140	1012
28	CYPERMETHRIN 2	62.301	0.04381	ppm	40	4974	492
29	CYPERMETHRIN 3	62.520	0.04148	ppm	41	5044	508
30	CYPERMETHRIN 4	62.666	0.04436	ppm	42	6035	516
31	FENVALERATE 1	65.044	0.04690	ppm	43	14918	1034
32	FENVALERATE 2	65.914	0.05405	ppm	44	4499	329



ID#	Name	Ret. Time	Conc.	Units	Peak#	Area	Height
1	PHORATE	10.559	0.05149	ppm	9	12286	1231
2	ALPHA HCH	10.971	0.05020	ppm	10	97489	10847
4	BETA HCH	12.704	0.05043	ppm	11	20399	2222
5	LINDANE	12.892	0.05048	ppm	12	54421	5543
6	FLUCHLORALIN	14.199	0.05102	ppm	13	76226	8817
7	DELTA HCH	14.697	0.05166	ppm	14	43436	3415
8	METHYL PARATHION	17.613	0.04969	ppm	16	26028	1772
9	MALATHION	20.889	0.05089	ppm	17	15226	1536
10	CHLORPYRIPHOS	21.794	0.04963	ppm	18	84391	7565
11	PENDIMETHALIN	24.838	0.05015	ppm	20	51957	3833
12	QUINALPHOS	26.013	0.04423	ppm	21	5236	420
13	ALPHA ENDOSULPHAN	28.033	0.04962	ppm	24	112580	11800
14	PROFENOPHOS	30.655	0.04935	ppm	27	8969	870
15	PP DDE	30.932	0.04980	ppm	28	123629	8592
16	BETA ENDOSULPHAN	33.886	0.05103	ppm	29	94645	9194
17	PP DDD	35.386	0.05106	ppm	30	69028	3721
18	ETHION	36.008	0.04934	ppm	31	43152	3196
19	ENDOSULPHAN SULPHATE	38.459	0.04950	ppm	32	33506	3195
21	BIFENTHRIN	47.702	0.04774	ppm	33	38161	2192
22	FENPROPATHRIN	48.558	0.04540	ppm	34	27519	1251
23	PHOSALONE	51.988	0.04707	ppm	35	10256	348
24	LAMBDA CYHALOTHRIN	54.980	0.04992	ppm	36	38541	2752
25	CYFLUTHRIN 1	61.413	0.04762	ppm	37	6936	823
26	CYFLUTHRIN 2	61.591	0.04612	ppm	38	13916	1209
27	CYPERMETHRIN 1	61.850	0.04397	ppm	39	14140	1012
28	CYPERMETHRIN 2	62.301	0.04381	ppm	40	4974	492
29	CYPERMETHRIN 3	62.520	0.04148	ppm	41	5044	508
30	CYPERMETHRIN 4	62.666	0.04436	ppm	42	6035	516
31	FENVALERATE 1	65.044	0.04690	ppm	43	14918	1034
32	FENVALERATE 2	65.914	0.05405	ppm	44	4499	329



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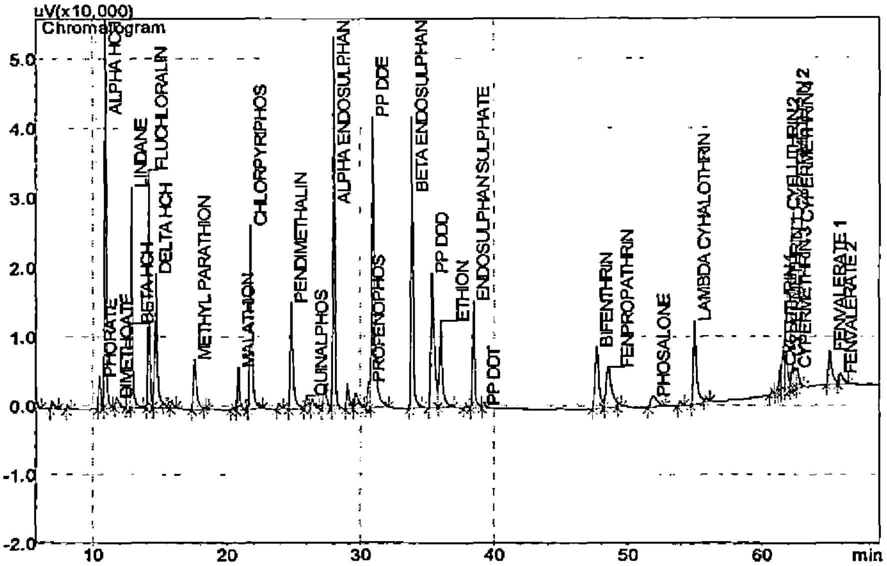
3	DIMETHOATE	11.686	0.07546	ppm	11	20399	2222
4	BETA HCH	12.778	0.07251	ppm	12	54421	5543
5	LINDANE	12.965	0.07211	ppm	13	76226	8817
6	FLUCHLORALIN	14.220	0.07426	ppm	14	43436	3415
7	DELTA HCH	12.223	0.07165	ppm	16	26028	1772
8	METHYL PARATHION	17.586	0.07658	ppm	17	15226	1536
9	MALATHION	10.111	0.07527	ppm	18	84391	7565
10	PHORATE	11.322	0.07211	ppm	20	51957	3833
11	PENDIMETHALIN	14.225	0.0702	ppm	21	5236	420
12	QUINALPHOS	12.014	0.0741	ppm	24	112580	11800
13	ALPHA ENDOSULPHAN	11.002	0.7542	ppm	27	8969	870
14	PROFENOPHOS	10.561	0.07251	ppm	28	123629	8592
15	PP DDE	10.241	0.07211	ppm	29	94645	9194
16	BETA ENDOSULPHAN	12.7723	0.07426	ppm	30	69028	3721
17	PP DDD	12.9604	0.07165	ppm	31	43152	3196
18	ETHION	14.2248	0.07658	ppm	32	33506	3195
19	ENDOSULPHAN SULPHATE	12.224	0.0750	ppm	33	38161	2192
21	BIFENTHRIN	17.586	0.7542	ppm	34	27519	1251
22	FENPROPATHRIN	14.021	0.07251	ppm	35	10256	348
23	PHOSALONE	12.321	0.07211	ppm	36	38541	2752
24	LAMBDA CYHALOTHRIN	10.221	0.07426	ppm	37	6936	823
25	CYFLUTHRIN 1	10.231	0.07474	ppm	38	13916	1209
26	CYFLUTHRIN 2	14.231	0.07411	ppm	39	14140	1012
27	CYPERMETHRIN 1	12.222	0.07546	ppm	40	4974	492
28	CYPERMETHRIN 2	12.331	0.07251	ppm	41	5044	508
29	CYPERMETHRIN 3	10.561	0.07211	ppm	42	6035	516
30	CYPERMETHRIN 4	10.661	0.07426	ppm	43	14918	1034
31	FENVALERATE 1	11.231	0.0722	ppm	44	4499	329
32	FENVALERATE 2	12.365	0.0745	ppm	9	12286	1231



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1	PHORATE	10.561	0.26579	ppm	10	51457	4746
2	ALPHA HCH	10.976	0.24391	ppm	11	551567	59859
3	DIMETHOATE	11.810	0.22600	ppm	12	26926	1450
4	BETA HCH	12.704	0.23587	ppm	13	116362	12230
5	LINDANE	12.900	0.23828	ppm	14	330758	31798
6	FLUCHLORALIN	14.205	0.27084	ppm	15	311278	34428
7	DELTA HCH	14.706	0.25116	ppm	16	264698	19428
8	METHYL PARATHION	17.613	0.27016	ppm	19	124588	7347
9	MALATHION	20.888	0.26710	ppm	22	68714	6206
10	CHLORPYRIPHOS	21.798	0.27174	ppm	23	334386	26551
11	PENDIMETHALIN	24.838	0.27211	ppm	25	231413	15448
12	QUINALPHOS	26.015	0.27066	ppm	26	28430	1980
13	ALPHA ENDOSULPHAN	28.034	0.26197	ppm	29	525098	53532
14	PROFENOPHOS	30.644	0.24811	ppm	32	42341	3850
15	PP DDE	30.939	0.25203	ppm	33	613481	41962
16	BETA ENDOSULPHAN	33.884	0.25461	ppm	34	442364	41930
17	PP DDD	35.374	0.24621	ppm	35	349533	19548
18	ETHION	36.013	0.26202	ppm	36	196066	12547
19	ENDOSULPHAN SULPHATE	38.463	0.25366	ppm	38	173325	15507
20	PP DDT	39.255	0.25232	ppm	39	5790	453
21	BIFENTHRIN	47.692	0.26524	ppm	40	180250	9024
22	FENPROPATHRIN	48.563	0.24934	ppm	41	168604	5943
23	PHOSALONE	51.960	0.26080	ppm	43	55223	1617
24	LAMBDA CYHALOTHRIN	54.988	0.26749	ppm	45	201620	12075
25	CYFLUTHRIN 1	61.411	0.26063	ppm	49	35756	3899
26	CYFLUTHRIN 2	61.620	0.26055	ppm	50	72542	5687
27	CYPERMETHRIN 1	61.852	0.26831	ppm	51	75224	5081
28	CYPERMETHRIN 2	62.300	0.26335	ppm	52	32522	2902
29	CYPERMETHRIN 3	62.495	0.26844	ppm	53	31813	3060
30	CYPERMETHRIN 4	62.657	0.24766	ppm	54	41069	2854
31	FENVALERATE 1	65.081	0.25764	ppm	55	89594	4851
32	FENVALERATE 2	65.923	0.25347	ppm	56	29283	1600

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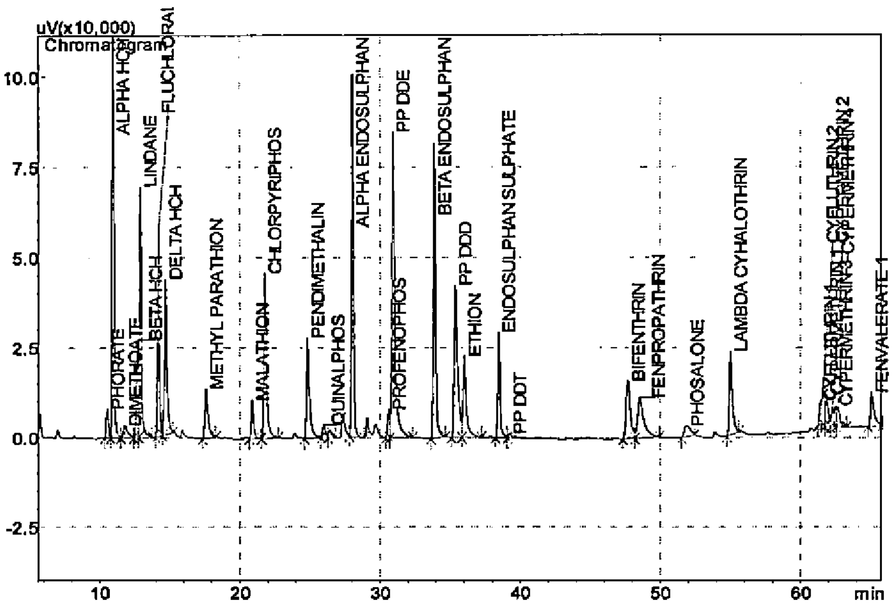

ID#	Name	Ret. Time	Conc.	Units	Peak#	Area	Height
1	PHORATE	10.560	0.49139	ppm	1	92691	8208
2	ALPHA HCH	10.975	0.50444	ppm	2	1162237	122407
3	DIMETHOATE	11.803	0.51550	ppm	3	74514	3471
4	BETA HCH	12.708	0.50925	ppm	4	257837	27131
5	LINDANE	12.910	0.50533	ppm	5	723697	69545
6	FLUCHLORALIN	14.198	0.48549	ppm	6	540799	57819
7	DELTA HCH	14.703	0.47610	ppm	7	514166	43240
8	METHYL PARATHION	17.610	0.47201	ppm	8	214820	13807
9	MALATHION	20.885	0.49022	ppm	9	123911	10823
10	CHLORPYRIPHOS	21.789	0.48840	ppm	10	578247	45842
11	PENDIMETHALIN	24.833	0.48523	ppm	11	403720	28005
12	QUINALPHOS	25.995	0.46132	ppm	12	47960	3526
13	ALPHA ENDOSULPHAN	28.029	0.49714	ppm	14	981952	100281
14	PROFENOPHOS	30.639	0.50931	ppm	15	86196	7841
15	PP DDE	30.923	0.50034	ppm	16	1214924	84739
16	BETA ENDOSULPHAN	33.874	0.49770	ppm	17	857586	81627
17	PP DDD	35.356	0.50441	ppm	18	720665	42408
18	ETHION	36.008	0.49235	ppm	19	361674	22629
19	ENDOSULPHAN SULPHATE	38.465	0.49675	ppm	20	339815	29372
20	PP DDT	39.248	0.48633	ppm	21	18224	1325
21	BIFENTHRIN	47.691	0.49187	ppm	22	328305	16207
22	FENPROPATHRIN	48.531	0.49925	ppm	23	341492	11392
23	PHOSALONE	51.910	0.42156	ppm	24	89046	3067
24	LAMBDA CYHALOTHRIN	54.972	0.46365	ppm	25	348652	23299
25	CYFLUTHRIN 1	61.397	0.45836	ppm	26	62509	7376
26	CYFLUTHRIN 2	61.584	0.45273	ppm	27	125085	10839
27	CYPERMETHRIN 1	61.845	0.46627	ppm	28	129127	9000
28	CYPERMETHRIN 2	62.271	0.45898	ppm	29	57069	5387
29	CYPERMETHRIN 3	62.486	0.46041	ppm	30	54455	5934
30	CYPERMETHRIN 4	62.634	0.48412	ppm	31	81817	5363
31	FENVALERATE 1	65.051	0.50001	ppm	32	175477	9568
32	FENVALERATE 2	65.902	0.50673	ppm	33	60757	3224

APPENDIX-III

Score card for Peppermint and coriander leaves

(Kindly indicate a tick mark in the appropriate columns)

Sl .no	Particulars	scores	T1	T2	T3	T4
1)	**Colour and Appearance**					
	Excellent	5				
	Very good	4				
	Good	3				
	Satisfactory	2				
	Fair	1				
2)	**Flavour**					
	Fresh flavour	5				
	High flavour	4				
	Moderate flavour	3				
	Fair flavour	2				
	Dull flavour	1				
4)	**Taste**					
	Fresh taste	5				
	High taste	4				
	Moderate taste	3				
	Fair taste	2				
	Dull taste	1				
4)	**Texture**					
	Excellent	5				
	Very good	4				
	Good	3				
	Fair	2				
	Poor	1				
5)	**Overall acceptability**					
	Like Extremely	5				
	Like Very Much	4				
	Like Moderately	3				
	Like Slightly	2				
	Dislike	1				

Date: Name:

Score card for Chilli, Ginger, cumin seed and fennel

(Kindly indicate a tick mark in the appropriate columns)

Sl .no	particulars	sco res	T1	T2	T3	T4
1)	**Colour and Apperance**					
	Excellent	5				
	Very good	4				
	Good	3				
	Satisfactory	2				
	Fair	1				
2)	**Flavour**					
	Very spicy	5				
	Moderately spicy	4				
	Fairly spicy	3				
	Less spicy	2				
	Piquant (Bland)	1				
4)	**Texture**					
	Excellent	5				
	Very good	4				
	Good	3				
	Fair	2				
	Poor	1				
5)	**Overall acceptability**					
	Like Extremely	5				
	Like Very Much	4				
	Like Moderately	3				
	Like Slightly	2				
	Dislike	1				