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The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2023; 12(5): 3474-3480

www.thepharmajournal.com
Received: 25-03-2023
Accepted: 30-04-2023

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Decontamination processing of tebuconazole and combination of fipronil and imidacloprid residues in chilli fruits

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Abstract
Field and laboratory experiments were carried out to investigate the effect of different decontamination processes on reduction of tebuconazole, fipronil (Including its metabolites viz., fipronil desulfinyl, fipronil sulfide and fipronil sulfone) and imidacloprid (including its metabolite, 6-chloronicotinic acid) residues in chilli fruits like tap water washing, lukewarm water washing, saline water washing, vinegar water washing, open pan cooking and microwave cooking after application of tebuconazole and a pre-mix formulation Lesenta 80 WG (fipronil 40% + imidacloprid 40%) on the crop. Tebuconazole and combination of fipronil + imidacloprid in chilli fruits were applied following the application @ 215 and 50 + 50 g a.i. ha^{-1} after spray, respectively. Chilli fruits were collected at 1,3 and 5 days interval after the last spray and subjected to decontamination processes. Washing of contaminated chilli samples provided 22.63-24.87, 20.33-24.33 and 22.22-25.76% relief from tebuconazole, ∑fipronil and imidacloprid residues, respectively from 1 to 5 day chilli fruits. Lukewarm water washing provided 32.66-34.50, 31.01-33.72 and 35.18-37.62% relief from tebuconazole, ∑fipronil and imidacloprid residues, respectively. Saline water washing removed tebuconazole, ∑fipronil and imidacloprid residues up to 43.50-48.95, 42.94-44.91 and 45.37-47.45%, respectively. Dipping of chilli fruits in 5 percent acetic acid for 5 minutes provided relief from tebuconazole, ∑fipronil and imidacloprid residues in the range of 62.50-64.88, 55.60-57.21 and 63.72-100.00%, respectively. Open pan cooking reduced tebuconazole, ∑fipronil and imidacloprid residues up to 81.37-100.00, 83.95-100.00 and 82.03-100.00%, respectively. Microwave cooking when cooked at 800W output in microwave for 5 minutes leads to reduction of tebuconazole, ∑fipronil and imidacloprid residues in the range of 93.62-100.00, 98.12-100.00 and 100.00% from 1-5 days contaminated chilli fruits, respectively. Decontamination of sprayed chilli fruits revealed that microwave cooking was most effective followed by open pan cooking and vinegar water washing.

Keywords: Chilli, tebuconazole, fipronil, imidacloprid, decontamination, metabolites

1. Introduction
Vegetables provide essential biochemical and nutrient components such as carbohydrates, carotene, proteins, vitamins, calcium, iron, ascorbic acid and trace mineral concentrations. (Jimoh and Oladiji, 2015) [1]. Among vegetables, chilli (*Capsicum annuum* L.) is a popular vegetable and commercial spice crop grown in tropical and sub-tropical regions around the world. It is a popular cash crop in India and is produced for its pungent fruits, which may be used both green and ripe to impart pungency to the food. Chilli is rich in vitamins A, C and E and is a common component in curries, pickles and chutnies (Kumar *et al*., 2000) [2].
With a 14 percent share, India is the world's second largest producer of vegetables, after China (48 percent). Vegetables are produced on 11065 thousand hectares in India, with an annual output of 199882 thousand metric tonnes (NHB, 2022) [3]. Chilies are produced on 1.14 thousand hectares in Himachal Pradesh, with an annual production of 13.48 thousand tonnes (NHB, 2022) [3]. Throughout its growing cycle, chilli is devastated by a high number of insect and acarine pests, which is one of the most significant restrictions to chilli output. Two of the 57 insect and mite pests known to cause yield loss in chillies are yellow mite (*Polyphagotarsonemus latus* Banks) (Acarina: Tarsonemidae) and thrips (*Scirtothrips dorsalis* Hood) (Thripidae: Thysanoptera) (Reddy and Puttaswamy, 1984 [4]; Desai *et al*. (2007) [5], Rai *et al*. (2014) [6]).

Chilli crop is also affected by different diseases like powdery mildew *Leveillula taurica*, fruit rot *Colletotrichum capsici*, bacterial wilt *Pseudomonas solanacearum*, soft rot *Erwinia carotovora* etc. Pesticides are primarily used by farmers to control insect pests and diseases. Imidacloprid and fipronil are reported to be effective against thrips, jassids and aphids. Powdery mildew and fruit rot are both treated with tebuconazole (Tomlin, 1994) [7]. Tebuconazole, fipronil, and imidacloprid are examples of systemic insecticides. Regardless of how they were applied or how they reached the plant, they translocate across all plant tissues, making them dangerous to any insects or fungal infections that attack it.

Consumers are concerned about the rising amount of pesticide residues in vegetables since insecticides leave residues on fruit that can last until harvest. Pesticide residues in vegetables also operate as a trade barrier, and certain consignments have been declined by imported countries due to tainted commodities (Kumari, 2015) [8]. Consumers may be exposed to pesticide residues in vegetables that exceed their respective maximum residue limits (Taneja, 2005) [9] may pose health hazards to consumers (Mukherjee and Gopal, 2003) [10]. As a result, it's necessary to emphasize the need of safe consumption. Because the chilli is eaten as a raw vegetable, insect control should be done with low-residue pesticides. As, chemicals are administered at various phases of crop growth and often prior to harvest, chilli retain residues of a mixture of chemicals, posing a health risk to consumers. It is critical to remove pesticide residues from vegetables before eating them. Various studies have demonstrated that processing reduces residues in prepared foods significantly, especially when washing, peeling, and boiling. As a result, it is critical to seek out low-cost, effective approaches that may be simply adopted at home. Keeping this in mind, the current research was undertaken to assess the impact of various household processing and laboratory techniques on reducing pesticide residues to a safe level for human consumption.

2. Materials and Methods

2.1 Chemical and reagents

Folicurs 430 SC and combi formulation Lesenta 80 WG containing fipronil 40% and imidacloprid 40% and certified reference materials of tebuconazole (purity, 99.70%), fipronil (purity, 99.20%), fipronil desulfinyl (MB046513) (purity, 97.80%), fipronil sulfide (MB045950) (purity, 98.00%), fipronil sulfone (MB046136) (purity 97.60%), imidacloprid (purity, 99.80%) and 6-chloronicotinic acid (purity, 99.7%) were obtained from M/s Bayer CropScience Ltd. Anhydrous magnesium sulfate, sodium chloride, sodium sulfate, and HPLC grade water were procured from Merck Specialties Pvt. Ltd. Worli, Mumbai. Primary secondary amine (PSA) was obtained from Agilent Technologies, USA. Reagents like acetone, acetonitrile, n-hexane were obtained from by M/s Genetix Biotech Asia Pvt. Ltd., New Delhi.

2.2 Preparation of Standard Solution

Stock solutions of fipronil and imidacloprid (400 mg/L) were prepared in acetone–hexane (0.5:9.5, v/v) and acetone–acetonitrile (0.5:9.5, v/v), respectively. Further, working standard solutions of 40, 10 and 1 ppm were prepared from stock solution by serial dilutions. There after, different lower concentrations viz., 0.05, 0.10, 0.25 and 0.50 ppm for tebuconazole, 0.001, 0.005, 0.010, 0.050 and 0.100 ppm for fipronil plus its metabolites and for imidacloprid and its metabolite 6-CNA, 0.05, 0.25, 0.50 and 1.00 ppm levels were prepared in mixture for analysis.

2.3 Instrumentation

Shimadzu Gas chromatograph with QP 2010 plus was supplied by Shimadzu corporation, Japan. Liquid Chromatograph SHIMADZU LC-20AT equipped with DGU-20A$_5$ degasser was also supplied by Shimadzu corporation, Japan. Agilent gas chromatogram with ECD was supplied by Agilent technologies, USA. Capillary column DB-5 (30m long, 0.25mm ID and 0.25µm film thickness) was acquired from Agilent. The Robot Coupe high volume homogenizer (Blixer® 6V.V) and low volume high speed homogenizer were supplied by Heidolph. Rotospin centrifuge tube shaker was acquired from Tarson Products Pvt. Ltd. The centrifuge was acquired from Eppendorf India Ltd. The turbo evaporator (Turbo Vap® LV) was procured from Caliper Life Science, Hopkinton.

2.4 Field experiment

The field experiment was conducted at the Entomological farm of Dr. YS Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh, India during the year 2017. Chilli (*Capsicum annuum*) variety Dhaulakuan Chilli-8 was raised and transplanted on 20th of April, 2017 at a spacing of 60×45 m between rows and plants, respectively, as per the package of practices of University (Anonymous, 2015). The field study was laid down in randomized block design with the 3 replications for each treatment to conduct the decontamination studies. The first application of pesticide tebuconazole and fipronil 40% + imidacloprid 40% was made at fruiting stage followed by second application at 10 days interval with standard dose of 215 and 50+50 g a.i. ha^{-1}, respectively. The insecticide was sprayed using a knapsack sprayer fitted with a solid cone nozzle.

2.5 Sample collection for decontamination studies

Chilli fruit samples (500 g) were randomly collected from each replication at an interval of 1, 3 and 5 days, after second foliar application of pesticide and then packed in polyethylene bags, well labelled and brought to laboratory for pesticide decontamination studies.

2.5.1 Decontamination processes

Samples collected from each replication were subjected to different common household processes viz. washing with running tap water, saline water, lukewarm water, vinegar water washing, open pan cooking and microwave cooking.

1. Tap water washing: Chilli fruits were hand rubbed and washed under tap water for 2 minutes before being dried in shade.
2. Lukewarm water washing: Treated chilli fruit samples were dipped in lukewarm water (35-40 °C) and hand rubbed for 5 minutes and dried in shade.
3. Saline water washing: Chilli fruit samples were dipped in water containing 2% NaCl and hand rubbed for 5 minutes and shade dried.
4. Vinegar water washing: Chilli fruits were dipped in 5% acetic acid (vinegar) water and hand rubbed for 5 minutes and then shade dried.
5. Open pan cooking: Chilli fruits were chopped into small pieces and cooked in an open pan till softness (10-15 minutes).

6. Microwave cooking: Chilli fruits were cut into small pieces and cooked at 800 W power output in microwave for 5 minutes.

After washing, the fruits were allowed to dry on filter paper before processing. After cooking, 15g equivalent of chilli material was taken for further processing and extracted the residues using QuEChERS method.

2.6 Extraction and cleanup with the QuEChERS method

The residues of tebuconazole, fipronil (along with its metabolites) and imidacloprid residues were extracted and analysed by modified QuEChERS method as per Sharma (2013) [11]. Chilli (500 g) fruit samples were chopped and crushed in Robot coupe high volume homgenizer. The 15 g homogenised sample was transferred to a 50 ml polypropylene centrifuge tube containing 30 ml HPLC grade acetonitrile and homogenised in a high speed homogenizer for 2 minutes at 15000 rpm. Then 3g sodium chloride was added, and the tube was shaken at 50 rpm in rotospin for 3 minutes before centrifuging at 3000 rpm for 3 minutes. To eliminate moisture, the 18 ml supernatant layer was transferred to a 50 ml centrifuge tube and 9 g anhydrous sodium sulphate was added. 11 ml of extract was taken into a 15 ml polypropylene centrifuge tube containing 400 mg primary secondary amine (PSA) sorbent and 1150 mg anhydrous magnesium sulphate after the moisture was removed. The sample tube was capped, agitated in a Rotospin mixer for 3 minutes at 50 rpm, and then centrifuged for 5 minutes at 3000 rpm. In the Turbovap concentrator, a 6 ml extract was put into glass test tubes and evaporated to dryness in an air current at 45ºC. The residues of pesticides viz. tebuconazole and fipronil were dissolved in 3 ml n-hexane for gas chromatographic (GC) analysis whereas for imidacloprid, the residues were dissolved in 3 ml of acetonitrile: water (30:70), and injected into HPLC for residue analysis.

2.7 Estimation and confirmation of residues

The residues of tebuconazole, fipronil and imidacloprid were analysed on GC-MS (Gas Chromatography-Mass Spectrometry), GC-ECD (Gas Chromatography-Electron Capture Detector) and HPLC (High Performance Liquid Chromatography), respectively. The operating parameters of above mentioned instrument are given in Table 1, 2 and 3.

Table 1: Operated GC-MS parameters

Gas Chromatograph	Shimazdu GC 2010
Detector	GCMS-QP 2010 plus
Column	capillary column (DB-5, 30 m long, 0.25 mm ID. and 0.25µm film thickness)
Injector temp.	250 °C
Ion source temp.	200 °C
Interface temp.	280 °C
Carrier Gas	Helium gas
Carrier gas flow	1.02 ml min^{-1}
Column Oven Temperatures	80 °C for 3 minutes, raised to 180 °C @ 20 °C min^{-1} and hold for 2 minutes followed by increase to 280 °C @ 5 °C min^{-1} with the hold time of 10 minutes.
Selected ions (SIM mode)	125, 70, 250 and 83 m/z

Table 2: Operated GC-ECD parameters

Gas Chromatograph	Agilent 6890N
Detector	ECD
Column	capillary column (DB-5, 30m long, 0.25mm ID. and 0.25µm film thickness)
Injector temp.	250°C
Carrier Gas	nitrogen gas
Carrier gas flow	1.00 ml min^{-1}
Column Oven Temperatures	80 ºC for 3 minutes, raised to 180 ºC @ 30 ºC min^{-1}, 2 min. Hold, again oven temp. raised to 205 °C @ 3 ºC min^{-1}, 0 min. Hold and finally raised to 260 °C for 15 min. @ 10 ºC min^{-1}
ECD	300 °C

Table 3: Operated HPLC parameters

Liquid Chromatograph	SHIMADZU LC-20AT
Detector	SPD-M20A Photodiode Array Detector (PDA) equipped with DGU-$20A_5$ degasser
Column	RP C_{18} (5 µm) column (2.1 mm X 30 cm)
Auto injector	SIL-20 AHT
Mobile phase	acetonitrile and water (30:70)
Run mode	isocratic mode
Flow rate	1 ml min^{-1}
Wavelength	270nm

3. Results and Discussion

3.1 Method Validation

In order to validate the analytical method, recovery experiments were carried out at different concentration levels. Chilli fruit control samples were spiked 0.05, 0.10, 0.25 and 0.50 ppm level of teboconazole, 0.001, 0.005, 0.01, 0.05 and 1.00 ppm levels for fipronil and its metabolites (fipronil desulfinyl, fipronil sulfide and fipronil sulfone) and for imidacloprid and its metabolite (6-CNA), control samples were spiked with 0.05, 0.25, 0.50 and 1.00 ppm levels, respectively. The average recovery of tebuconazole from fortified chilli fruits was ranged between 94.00-98.00 percent. The average recoveries of fipronil, Fipronil desulfinyl, Fipronil sulfide and Fipronil sulfone were ranged between

90.00-108.00, 99.80-108.00, 90.00-98.00 and 85.40-98.00 percent, respectively. The average recovery for imidacloprid and its metabolite, 6-CNA was ranged between 91.20-102.00 and 79.40-102.00 percent, respectively from chilli fruits. The recovery obtained of all the pesticides in chilli fruits was in the acceptable range of 80-120 percent as per SANTE guidelines (SANTE, 2019) [12], thus establishing the suitability of method for further studies.

3.2 Decontamination

3.2.1 Tap Water Washing

Washing with water before cooking is the cheapest and easiest method of cleaning dirt particles from vegetables (Krol *et al.*, 2000) [13]. It was observed that washing of pesticides treated chilli fruits under running tap water reduced residues of tebuconazole, ∑fipronil and imidacloprid up to 22.63-24.87, 20.33-24.33 and 22.22-25.76% in 1 to 5 day treated chilli fruits, respectively (Table 4 and 5; Fig. 1, 2 and 3). After tap water washing, 11.11-14.92, 81.57-100.00, 44.44-100 and 62.5-100.00 percent reduction from residues of parent molecule fipronil, fipronil desulfinyl, fipronil sulfide and fipronil sulfone was also obtained, respectively (Table 5). According to Hendawi *et al.* (2013) [14], removal of imidacloprid from strawberry was in the range of 9.9-30.55% by washing with tap water.

Table 4: Effect of culinary processes on tebuconazole and imidacloprid residues in chilli fruits

Treatments	Days	Tebuconazole		Imidacloprid	
		Mean residues (mg kg^{-1}) ± SD	Relief (%)	Mean residues (mg kg^{-1}) ± SD	Relief (%)
Unprocessed	1	0.800±0.084	-	0.412±0.003	-
	3	0.450±0.039	-	0.295±0.004	-
	5	0.212±0.025	-	0.108±0.004	-
Tap water washing	1	0.601±0.005	24.87	0.312±0.004	24.27
	3	0.342±0.002	22.63	0.219±0.003	25.76
	5	0.163±0.004	24.47	0.084±0.006	22.22
Lukewarm water washing	1	0.524±0.004	34.50	0.26±0.004	36.89
	3	0.303±0.004	32.66	0.184±0.004	37.62
	5	0.141±0.005	33.49	0.070±0.007	35.18
Saline water washing	1	0.452±0.004	43.50	0.22±0.006	46.6
	3	0.241±0.004	46.44	0.155±0.005	47.45
	5	0.118±0.006	48.95	0.059±0.005	45.37
Vinegar water washing	1	0.300±0.006	62.50	0.141±0.003	65.77
	3	0.158±0.006	64.88	0.107±0.005	63.72
	5	0.077±0.006	63.67	BDL	100.00
Open Pan Cooking	1	0.149±0.008	81.37	0.071±0.002	82.76
	3	0.074±0.004	83.55	0.053±0.003	82.03
	5	BDL	100.00	BDL	100.00
Microwave Cooking	1	0.051±0.001	93.62	BDL	100.00
	3	BDL	100.00	BDL	100.00
	5	BDL	100.00	BDL	100.00

Table 5: Effect of culinary processes on fipronil and its metabolites residues in chilli fruits

Treatments	Interval (Days)	Fipronil desulfinyl		Fipronil sulfide		Fipronil		Fipronil sulfone		∑ Fipronil	
		Mean residues (mg kg^{-1}) ± SD	Percent Relief	Mean residues (mg kg^{-1}) ± SD	Percent Relief	Mean residues (mg kg^{-1}) ± SD	Percent Relief	Mean residues (mg kg^{-1}) ± SD	Percent Relief	Mean residues (mg kg^{-1}) ± SD	Percent Relief
Unprocessed	1	0.038±0.003	-	0.009±0.001	-	0.315±0.005	-	0.012±0.0005	-	0.374±0.005	-
	3	0.024±0.003	-	0.005±0.0005	-	0.207±0.003	-	0.008±0.0005	-	0.241±0.002	
	5	0.013±0.002	-	0.002±0.0005	-	0.149±0.003	-	0.005±0.0005	-	0.17±0.005	
Tap water Washing	1	0.007±0.001	81.57	0.005±0.0005	44.44	0.268±0.003	14.92	0.003±0.0005	75.00	0.283±0.002	24.33
	3	0.003±0.0005	87.5	0.002±0.0005	60.00	0.184±0.003	11.11	0.003±0.0005	62.5	0.192±0.002	20.33
	5	BDL	100.00	BDL	100.00	0.132±0.009	11.40	BDL	100	0.132±0.009	22.35
Lukewarm water washing	1	0.004±0.005	89.47	0.002±0.0005	77.77	0.251±0.003	20.31	0.001±0.0005	91.66	0.258±0.002	31.01
	3	0.001±0.0005	95.83	BDL	100.00	0.162±0.002	21.73	BDL	100.00	0.163±0.002	32.36
	5	BDL	100.00	BDL	100.00	0.112±0.002	24.83	BDL	100.00	0.112±0.002	33.72
Saline water washing	1	0.001±0.0005	97.36	BDL	100.00	0.205±0.001	34.92	BDL	100.00	0.206±0.001	44.91
	3	BDL	100.00	BDL	100.00	0.137±0.001	33.81	BDL	100.00	0.137±0.001	43.15
	5	BDL	100.00	BDL	100.00	0.097±0.002	34.89	BDL	100.00	0.097±0.002	42.94
Vinegar washing	1	BDL	100.00	BDL	100.00	0.16±0.002	49.20	BDL	100.00	0.16±0.002	57.21
	3	BDL	100.00	BDL	100.00	0.107±0.003	48.30	BDL	100.00	0.107±0.003	55.60
	5	BDL	100.00	BDL	100.00	0.075±0.003	49.66	BDL	100.00	0.075±0.003	55.88
Open Pan Cooking	1	BDL	100.00	BDL	100.00	0.06±0.005	80.95	BDL	100.00	0.06±0.005	83.95
	3	BDL	100.00	BDL	100.00	0.029±0.002	85.99	BDL	100.00	0.029±0.002	87.96
	5	BDL	100.00	BDL	100.00	BDL	100.00	BDL	100.00	BDL	100.00
Microwave Cooking	1	BDL	100.00	BDL	100.00	0.007±0.0005	97.77	BDL	100.00	0.007±0.0005	98.12
	3	BDL	100.00	BDL	100.00	BDL	100.00	BDL	100.00	BDL	100.00
	5	BDL	100.00	BDL	100.00	BDL	100.00	BDL	100.00	BDL	100.00

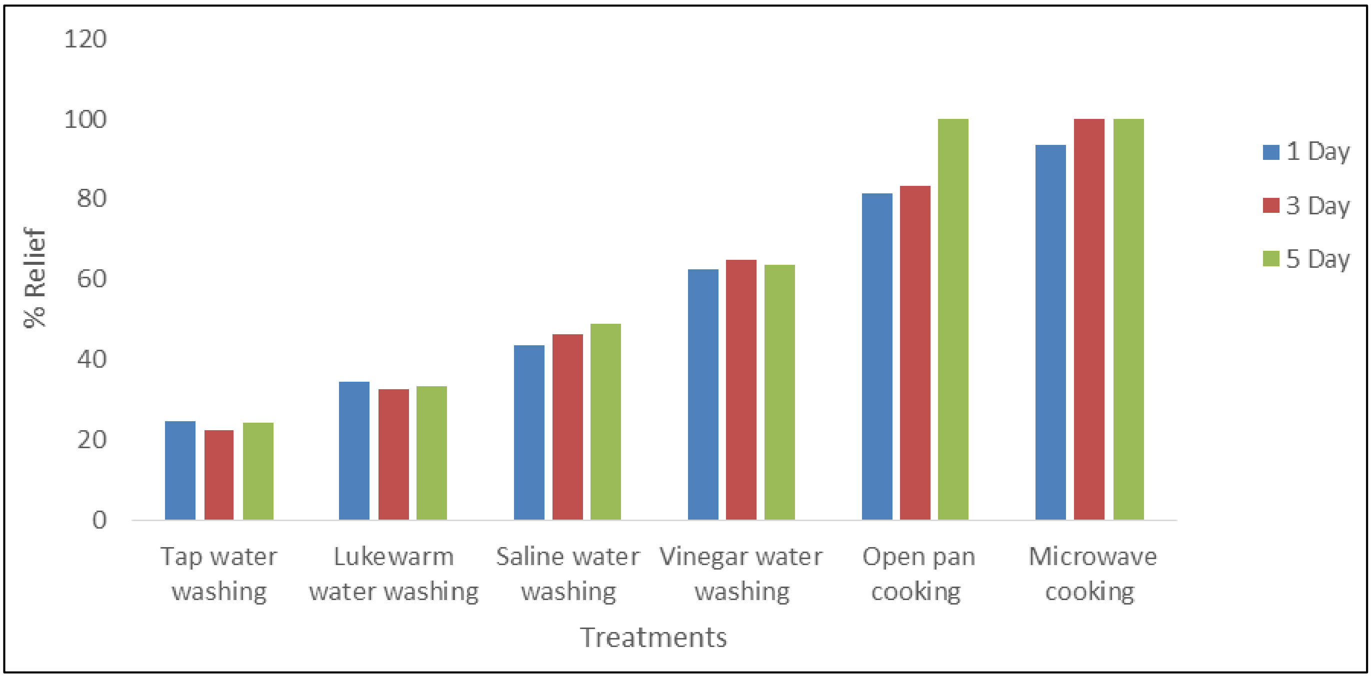

Fig 1: Effect of culinary processes on tebuconazole residues in chilli fruits

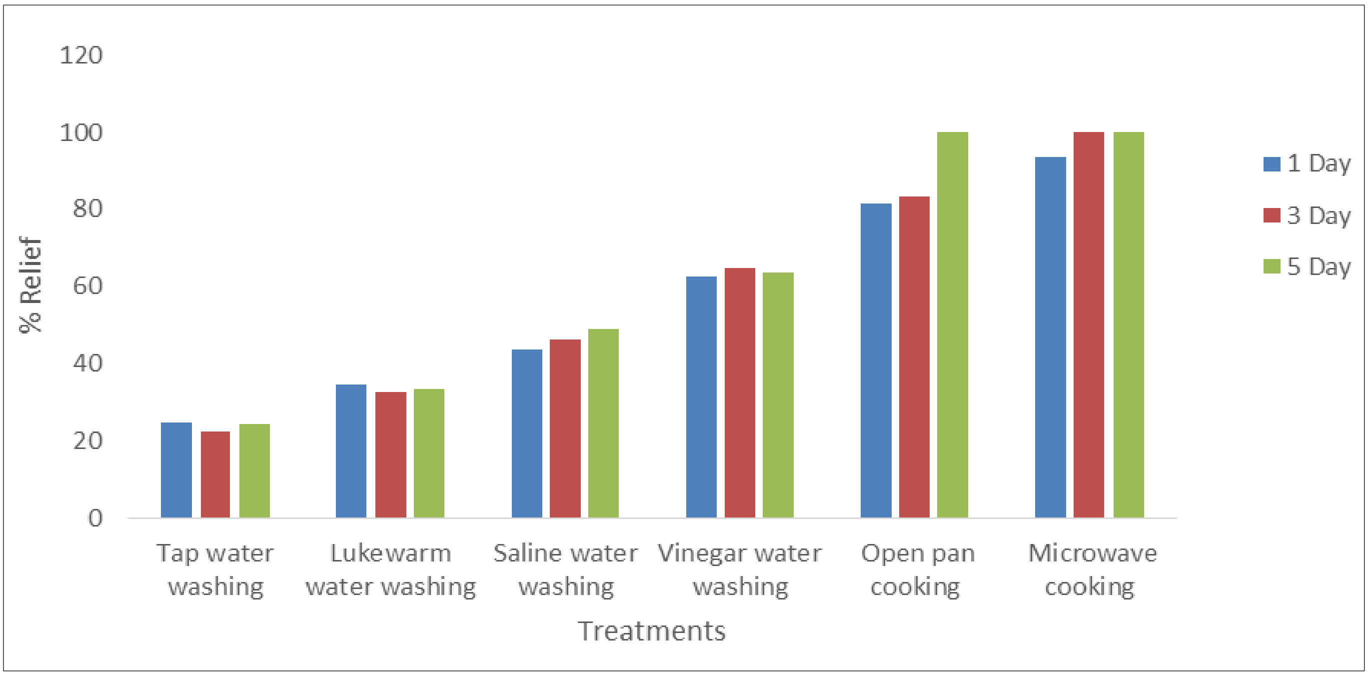

Fig 2: Effect of culinary processes on ∑fipronil residues in chilli fruits

3.2.2 Lukewarm water washing

In lukewarm water (35-40 °C) washing, chilli fruits were dipped for 5 minutes which provided a% relief of 32.66-34.50, 31.01-33.72 and 35.18-37.62 from tebuconazole, ∑fipronil and imidacloprid residues, respectively in 1 to 5 day treated chilli fruits, respectively (Table 4 and 5; Fig. 1, 2 and 3). Residues of parent molecule fipronil, fipronil desulfinyl, fipronil sulfide and fipronil sulfone reduced up to 20.31-24.83, 89.47-100.00, 77.77-100.00 and 91.66-100.00%, respectively by lukewarm water washing of chilli fruits (Table 5). According to Banshtu and Patyal (2015) [15], removal of chlorpyriphos residues from tomato fruits was increased upon luke warm water washing (38.98-43.09%) in comparison to washing tomato fruits under running tap water (35.99-40.02%).

3.2.3 Saline water washing

Saline water washing dislodged residues of tebuconazole, ∑fipronil and imidacloprid up to 43.50-48.95, 42.94–44.91 and 45.37-47.45%, respectively in 1 to 5 day treated chilli fruits (Table 4 and 5; Fig. 1, 2 and 3). Residues of parent molecule fipronil and fipronil desulfinyl reduced to 33.81-34.92 and 97.36-100.00% in 1 to 5 day treated chilli fruits, respectively. In case of fipronil sulfide and fipronil sulfone, 100.00% relief was obtained from residues after saline water washing (Table 5). Satpathy *et al.* (2012) [16] reported that washing of vegetables with 0.9% NaCl reduced the residues by 20-89%. According to Chandra *et al.* (2015) [17], 68.0-69.4% pesticide residues were effectively removed from okra fruits after washing in a 2% salt solution followed by washing with tap water. As per Kumar *et al.* (2000) [18], 90.56 and

66.93% insecticide residues were removed from chillies at 0 and 5 days, respectively, when green chilies were immersed in a 2% salt solution for 10 minutes before being washed in water.

3.2.4 Vinegar water washing
Dipping in vinegar solution provided 62.50-64.88, 55.80-57.21 and 63.72-100.00% relief from residues of tebuconazole, ∑fipronil and imidacloprid, respectively in 1 to 5 day treated chilli fruits (Table 4 and 5; Fig. 1, 2 and 3). In case of fipronil desulfinyl, fipronil sulfide and fipronil sulfone, 100.00% relief was obtained after vinegar dipping (Table 5). According to Zohair (2001) [19], acidic reagents like acetic acid, ascorbic acid and citric acid were more effective at removing pesticide residues than neutral or alkaline solutions, as well as plain water. As per Satpathy *et al.* (2012) [16], washing raw *Spondias pinnata* with 0.1 percent acetic acid reduced pesticide residues by 20-89 percent. Xavier *et al.* (2014) [20] reported that ∑fipronil residues reduced from 0.85 g g^{-1} and 0.707g g^{-1} to 0.054 g g^{-1} and 0.045 g g^{-1}, respectively in 0 and 1 day processed chilli fruit samples when treated with 2 percent vinegar solution.

3.2.5 Open pan cooking
Open pan cooking provided 81.37-100, 83.95-100.00 and 82.03-100.00% relief from tebuconazole, ∑fipronil and imidacloprid residues from 1 to 5 day treated chilli fruit, respectively (Table 4 and 5;Fig. 1, 2 and 3). No residues of fipronil desulfinyl, fipronil sulfide and fipronil sulfone were found in 1st, 3rd and 5th day treated chilli fruits (Table 5). According to Reddy *et al.* (2014) [21], cooking tomato samples lowered pesticide residues by 42.9-83.2 percent.

3.2.6 Microwave cooking
Data presented in Table 4 and 5 showed that microwave cooking provided 93.62-100.00 and 98.12-100.00% relief from tebuconazole and ∑fipronil residues when cooked at 800 W power output in microwave for 5 minutes in 1 to 5 day treated chilli fruits, respectively (Fig. 1, 2 and 3). No residues of metabolites of fipronil and imidacloprid were found on 1st, 3rd and 5th day and showed 100% relief (Table 4 and 5). Our investigation got support from the study of Hanafi *et al.* (2016) [22] who reported that microwave cooking removed 90.00% of pesticide residues in okra fruits. According to Rodrigues *et al*. (2002) [23], 94-99% relief from chlorpyriphos and dichlorvos residues were obtained in rice and beans after cooking in a microwave oven at powers of 500 and 800W for 15-45 minutes.

4. Conclusion
Microwave cooking was reported to be the most effective decontamination method, followed by open pan cooking, vinegar water washing, saline water washing, lukewarm water washing, and tap water washing. Different culinary processes/household practices contribute significantly to reduce the risk of residual pesticides, hence, chilli fruits should be washed under running tap water before cooking to reduce pesticide concentration in cooked meals.

5. Acknowledgement
Authors are grateful to the Department of Entomology, Dr.YS Parmar University of Horticulture and Forestry, Nauni, Solan (H.P.) all All India Network Project on Pesticide Residues (AINP) for providing necessary facilities and constant encouragement.

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