

Impact of Medicated Vegetable Wash versus Lukewarm Water on Pesticide Residue Levels in *Brassica oleracea*: An In-vitro Study

KRUP VASAVDA¹, REKHA PARMAR², RAVI KALSARIYA³, HEMANT TOSHIKHANE⁴

ABSTRACT

Introduction: Fresh vegetables and fruits are essential sources of micronutrients and macronutrients vital for human health. Pesticides are primarily employed to enhance agricultural yield; however, it is important to recognise that they pose significant risks to human health. These chemicals can be toxic and may cause acute or chronic health effects depending on the nature, duration, and level of exposure.

Aim: To evaluate the effectiveness of different medicated vegetable washes in removing pesticide residues from *Brassica oleracea*.

Materials and Methods: This in-vitro study was conducted at the All India Network Project on Pesticide Residues, ICAR Unit-9, Anand Agricultural University, Anand, Gujarat, India. The study focused on three commonly used pesticides: chlorantraniliprole, emamectin benzoate, and chlorpyrifos. Succulent cauliflower

(*Brassica oleracea*) was selected as the test vegetable and was exposed to the selected pesticides. Residue analysis was performed using advanced gas chromatography-mass spectrometry (GC-MS/MS).

Results: The results demonstrated a substantial reduction in pesticide residues, with removal rates of 80.52%, 58.82%, and 36.02% for chlorantraniliprole, emamectin benzoate, and chlorpyrifos, respectively. The greatest reduction was achieved using medicated water, followed by lukewarm water, highlighting a promising approach in enhancing food safety.

Conclusion: Medicated water was effective in reducing pesticide residues on vegetables. Increasing public awareness of this method and promoting traditional washing practices may enhance food safety and provide consumers with healthier produce.

Keywords: Decontamination, Chlorantraniliprole, Emamectin benzoate, Chlorpyrifos

INTRODUCTION

Fresh vegetables play a crucial role in a healthy diet, serving as rich sources of essential vitamins and minerals, with cauliflower being a notable example [1]. However, it is important to recognise that this palatable vegetable may contain harmful chemical residues, including pesticides, which could pose potential health risks to consumers. As vegetables are traded globally, the specific pesticides used during cultivation often remain unknown, underscoring the need for greater awareness and vigilance in food selection [2,3]. Globally, pesticide consumption is estimated to be approximately 2 million tonnes annually [4]. Pesticides are essential for protecting crops from weeds, rodents, insects, and pathogens, thereby increasing agricultural productivity. However, for a long time, their use was poorly regulated. The application of pesticides is not without drawbacks, as it can result in various health and environmental hazards, including headache, blurred vision, and excessive salivation to seizures, coma, and even death, depending on the dose and duration of exposure [5].

The commonly used pesticides selected for this study—chlorantraniliprole, emamectin benzoate, and chlorpyrifos—represent a diverse group of organic and inorganic compounds. These chemicals are classified based on the organisms they target, such as herbicides, acaricides, nematocides, fungicides, insecticides, and rodenticides. However, many pesticides are non selective and can eliminate not only target pests but also natural predators and beneficial organisms within the ecosystem [1].

Agadtantra (toxicology) is one of the eight branches (*Ashtangas*) of Ayurveda that focuses on poisons derived from both living and non living sources [6]. It offers detailed knowledge of various decontamination methods, including the purification of water, soil, and air. Washing vegetables is considered a critical procedure to

remove contaminants [7]. Ayurvedic texts also describe the use of specific herbal formulations for water purification [8].

Accordingly, this study was undertaken to assess pesticide residues in vegetables washed with lukewarm water and compare them with those washed using *Dhava-Aswakarnadi* modified medicated water. Although several studies [1,5] have explored decontamination methods, this research is unique in its focus on a traditional herbal vegetable wash. The use of readily available ingredients enhances the practicality and feasibility of incorporating this method into daily household practices.

MATERIALS AND METHODS

This in-vitro study was conducted at the All-India Network Project on Pesticide Residues and Contaminants, Pesticide Residue and Contaminant Testing Laboratory, Anand Agricultural University, Anand, Gujarat, India (ISO/IEC 17025:2017 and NABL-accredited since 2012), from June to September 2025. Ethical clearance for the study was obtained (Ethical Clearance No. PU/PIA/IEC/07/2023/290).

Preparation of Medicated Water

Here, the medicated water preparation follows the *Kshara Kalpana Vidhi* by *Acharya Vagbhata*.

Plant Materials

Dhava (*Anogeissus latifolia* Roxb.), *Haridra* (*Curcuma longa* Linn.), *Paribhadra* (*Erythrina variegata* Lam.), *Patala* (*Stereospermum suaveolens* DC.), *Siddhaka* (*Vitex negundo* Linn.), *Mokshaka* (*Schrebera swietenoides* Roxb.), *Aaragvadha* (*Cassia fistula* Linn.), *Katphala* (*Myrica esculenta* Buch.-Ham.), *Neem* (*Azadirachta indica* A. Juss.), *Arishtaka* (*Sapindus emarginatus* Vahl), and *Yastimadhu* (*Glycyrrhiza glabra* Linn.) were collected from the Gir Forest, Gir

Somnath District, Gujarat State, India. The plant materials were authenticated by a taxonomist in the Department of Botany, J & J Science College, Nadiad, Gujarat, India.

A large iron kadayi was sterilised using a flame gun. Each plant material (300 g) was placed in the kadayi and ignited using the flame gun. The ash formed was collected and stored for further use [Table/Fig-1,2] [8].



[Table/Fig-1]: Raw drugs procured.

S. No.	Drug	Latin Name	Family
1	Dhava	<i>Anogeissus latifolia</i> Roxb.	Combretaceae
2	Haridra	<i>Curcuma longa</i> Linn	Zingiberaceae
3	Paribhadra	<i>Erythrina Variegata</i> Lam	Fabaceae
4	Patala	<i>Stereospermum suaveolens</i> DC	Bignoniaceae
5	Siddhaka	<i>Vitex negundo</i> Linn	Verbenaceae
6	Mokshaka	<i>Schrebera swietenioides</i> Roxb	Oleaceae
7	Aaragvadha	<i>Cassia fistula</i> Linn	Caesalpinioideae
8	Katphala	<i>Myrica esculenta</i> Buch-Ham	Myricaceae
9	Neem	<i>Azadirachta indica</i> A. Juss	Meliaceae
10	Arishtaka	<i>Sapindus emarginatus</i> Vahl	Sapindaceae
11	Yastimadhu	<i>Glycyrrhiza glabra</i> Linn.	Leguminosae

[Table/Fig-2]: Details of the plant materials used.

Procedure

About 100 gms of the prepared ash was weighed and transferred into a clean, dry steel vessel. Six parts (600 g) of distilled water were added to the ash and stirred for 5 minutes. The vessel was then covered with a clean cotton cloth and left undisturbed overnight. The following day, the supernatant was filtered seven times using a four-folded cotton cloth into another vessel. After filtration, approximately 510 mL of liquid was obtained. This filtrate was transferred to a large steel vessel, boiled, and reduced to half its volume. To the boiling solution, 11 ingredients—*Dhava*, *Haridra*, *Paribhadra*, *Patala*, *Siddhaka*, *Mokshaka*, *Aaragvadha*, *Katphala*, *Neem*, *Arishtaka*, and *Yastimadhu*—were added in paste (*kalka*) form. The total quantity of these *Prativapa dravyas* (drugs added after the main procedure) was 6.6 g. The mixture was boiled again and reduced to half. The final medicated water was stored in a sterile 200 mL glass bottle under aseptic conditions to minimise environmental exposure and contamination [Table/Fig-3] [9].

Sample Preparation

Pesticide spray on cauliflower: Cauliflower was grown in a farmer's field (approximately half an acre) in the villages of Navli and Pratij using organic farming practices without pesticide application, serving as the control. Six separate cauliflower plots (approximately half an acre each) were sprayed with the pesticides chlorantraniliprole, emamectin benzoate, and chlorpyrifos at recommended doses. [Table/Fig-4].

Collection of cauliflower: Ten medium-sized, well-grown cauliflowers were randomly collected 48 hours after pesticide spraying from the farmer's fields. The pesticides applied in each field were documented.



Preparation of Medicated Water



[Table/Fig-3]: Preparation of medicated water.



[Table/Fig-4]: Spray of different pesticides.

Methodology: After collection, the cauliflowers were cut into small pieces. Representative samples of cauliflower curds weighing 1 kg were subjected to different washing treatments.

Washing Experiments

Details of the washing experiments are shown in [Table/Fig-5]. For each treatment, three replicates were analysed. The treatments were as follows:

T1 (Control): Representative cauliflower curd samples collected from insecticide-treated plots without washing.

T2: Soaked in 2 L of lukewarm water (45-50° C) and stirred continuously for 10 minutes.

T3: Soaked in 2 L of 1% *Dhava*-*Aswakarnadi* modified medicated water and stirred continuously for 10 minutes [Table/Fig-5].



[Table/Fig-5]: Washing of collected cauliflower samples.

Extraction of cauliflower samples: Cauliflower curds were chopped into small pieces and homogenised using a homogeniser. A representative 15 g portion of the homogenised sample was weighed and transferred into a 50 mL centrifuge tube. The sample was extracted with 15 mL of extractant solution (acetonitrile containing 1% acetic acid) and placed in a deep freezer for 20 minutes.

Subsequently, 6.0 g of magnesium sulfate ($MgSO_4$) and 1.5 g of sodium acetate were added, and the mixture was vortexed for

1 minute. The sample was then centrifuged at 3500 rpm for 5 minutes. Six millilitres of the supernatant was transferred into a 15 mL centrifuge tube containing 0.9 g of $MgSO_4$ and 0.3 g of PSA. This mixture was shaken vigorously for 1 minute and centrifuged at 2500 rpm for 2 minutes.

One millilitre of the final supernatant (equivalent to 1 g of the original sample) was taken for the estimation of GC-amenable compounds, namely chlorantraniliprole, emamectin benzoate, and chlorpyrifos [10].

Ratio of ingredients for medicated water: The quantities used for the preparation of kshara were as follows:

Ash : Water : *Prativapa Dravya* = 1 : 6 : 1/30 [Table/Fig-6]

Ingredients	Ash (1 Gm)	Water (6 Gm)	<i>Prativapa dravya</i> (1/30 Gms)
Quantity	200	1200	6.6
Approximately (part)	1	6	1/30 th
Medicated water (g)	100	600	3.3

[Table/Fig-6]: Ratio for ingredients for medicated water.

STATISTICAL ANALYSIS

Statistical analysis was performed using IBM Statistical Package for the Social Sciences (SPSS) Statistics software, version 27.0. Data were expressed as mean±Standard Deviation (SD). Critical difference values were calculated at p -value<0.05. One-way Analysis of Variance (ANOVA) was used to evaluate the effect of different washing treatments on pesticide residue levels compared with the control group.

RESULTS

In the study samples, chlorantraniliprole residues were reduced by 70.78% following washing with lukewarm water and by 80.52% with medicated water [Table/Fig-7]. Emamectin benzoate residues were reduced by 52.94% with lukewarm water and by 58.82% with medicated water [Table/Fig-8]. Chlorpyrifos residues showed reductions of 24.42% with lukewarm water and 36.02% with medicated water [Table/Fig-9]. The results revealed statistically significant differences in mean pesticide concentrations following the washing treatments (p -value<0.05). These findings clearly demonstrate that different water washes are effective in reducing pesticide residues on cauliflower [Table/Fig-10].

Treatment	Residue (ppm)	Average (ppm)	Standard Deviation	Degradation (%)
Untreated (Control)	0.394	0.616	0.18167	
	0.617			
	0.839			
Lukewarm water	0.170	0.180	0.01023	70.78%
	0.180			
	0.190			
<i>Dhava Aswakarnadi</i> modified medicated water	0.110	0.120	0.01018	80.52%
	0.120			
	0.130			

[Table/Fig-7]: Residues of chlorantraniliprole in cauliflower after various decontamination treatments.

DISCUSSION

The present study demonstrated that both lukewarm water and *Dhava-Aswakarnadi* (DA) Modified Water are effective methods for reducing pesticide residues in cauliflower curds. Specifically, soaking cauliflower in lukewarm water for 10 minutes resulted in a significant reduction in pesticide residues, achieving up to 24.42% removal of chlorpyrifos. Superior efficacy was observed with medicated water washing, with residue reduction ranging from 36-80% across the various pesticides studied.

These results suggest that simple and easily accessible washing techniques can substantially reduce harmful pesticide residues,

Treatment	Residue (ppm)	Average (ppm)	Standard Deviation	Degradation (%)
Untreated (Control)	0.073	0.085	0.0097	
	0.085			
	0.097			
Lukewarm water	0.038	0.040	0.0020	52.94
	0.040			
	0.042			
<i>Dhava Aswakarnadi</i> modified medicated water	0.032	0.035	0.0030	58.82
	0.035			
	0.038			

[Table/Fig-8]: Residues of emamectin benzoate in cauliflower after various decontamination treatments.

Treatment	Residue (ppm)	Average (ppm)	Standard Deviation	Degradation (%)
Untreated (Control)	24.499	25.799	1.0614	
	25.799			
	27.099			
Lukewarm water	18.439	19.499	1.0003	24.42
	19.561			
	20.500			
<i>Dhava Aswakarnadi</i> modified medicated water	15.532	16.481	1.0004	36.02
	16.500			
	17.468			

[Table/Fig-9]: Residues of chlorpyrifos in cauliflower after various decontamination treatments.

S. No.	Name of pesticide	f-value	p-value
1	Chlorantraniliprole	13.31	0.00620
2	Emamectin benzoate	43.47	0.00027
3	Chlorpyrifos	54.94	0.00012

[Table/Fig-10]: Pesticide wise comparison between the three groups. ANOVA, p <0.05: statistically significant

thereby enhancing the safety of vegetables for consumption. This finding is particularly relevant for populations such as those in India, where fresh vegetables constitute a major component of the daily diet. Moreover, the outcomes align with principles described in classical Ayurvedic texts on food purification, which advocate detoxification through water contact and specific processing methods. The present study provides empirical scientific validation of these traditional practices in a modern context.

Comparison with previous studies reveals similar trends regarding the effectiveness of washing methods in reducing pesticide residues. Acoglu B and Yolci Omeroglu P, reported that the use of different washing agents reduced pesticide residues in oranges by 2% to 84%, with the highest removal achieved using alkaline solutions such as sodium carbonate and the lowest with tap water [11]. Similarly, Yang SJ et al., demonstrated substantial reductions in pesticide levels in leafy vegetables following various washing protocols, with reductions ranging from 43.7% to 77.0% [12].

However, a notable strength of the present study was the use of a specifically formulated medicated water, which exhibited greater efficacy than several conventional washing methods reported in earlier literature. While routine washing procedures are effective to a certain extent, *Dhava-Aswakarnadi* modified medicated water showed enhanced residue removal, particularly for persistent pesticides such as chlorpyrifos.

Collectively, these findings highlight the value of integrating traditional knowledge systems with modern scientific research to improve food safety strategies. The results support the broader adoption of washing techniques that are not only effective but also culturally acceptable and practically feasible for diverse

populations. Given the increasing concerns regarding pesticide exposure and food safety, these findings may contribute to policy development and the formulation of best practices for both domestic consumption and export regulations, thereby promoting public health and safety.

Limitation(s)

The present study evaluated the effectiveness of the medicated wash on only one vegetable, cauliflower, and assessed residue levels of only three pesticides—chlorantraniliprole, emamectin benzoate, and chlorpyrifos. Consequently, the findings may not be directly generalisable to other vegetables, fruits, or classes of pesticides. Additionally, the medicated wash was tested at only a single concentration and soaking duration (10 minutes); therefore, optimal conditions for maximum pesticide removal were not explored. Furthermore, the preparation of the medicated water involves a multistep traditional process (*Kshara Kalpana Vidhi*) using 11 plant ingredients, which may present challenges related to standardisation and large-scale adoption by the general population.

CONCLUSION(S)

This study evaluated the effectiveness of different washing methods for removing pesticide residues from cauliflower and demonstrated that *Dhava-Aswakarnadi* modified medicated water is highly effective for this purpose. The findings, confirmed through GC–MS analysis, highlight the superior efficacy of medicated water washing compared to conventional methods. Common pesticides detected in cauliflower include chlorantraniliprole, emamectin benzoate, and chlorpyrifos, exposure to which has been associated with serious health risks such as arthritis, skin disorders, bone diseases, cancer, and neurological impairments.

Vegetables frequently contain pesticide residues, posing a significant public health concern. Rising levels of these residues have serious implications for both human health and the economy. Chemical contamination of crops and the food chain exposes humans and animals to harmful substances, necessitating effective mitigation

strategies. The present study demonstrates that targeted washing interventions, particularly the use of medicated water, can play a crucial role in reducing pesticide contamination. These findings support the implementation of scientifically validated, culturally rooted washing practices to enhance food safety and protect public health.

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PARTICULARS OF CONTRIBUTORS:

1. PhD Scholar, Department of Dravyaguna, Parul Institute of Ayurveda, Vadodara, Gujarat, India.
2. Professor, Department of Dravyaguna, Parul Institute of Ayurveda, Vadodara, Gujarat, India.
3. Assistant Residue Analyst, All India Network Project on Pesticide Residues & Contaminants (AINP-PR&C), Pesticide Residue Laboratory, ICAR Unit-9, Anand Agricultural University, Anand, Gujarat, India.
4. Dean, Faculty of Ayurved, Parul University, Vadodara, Gujarat, India.

NAME, ADDRESS, E-MAIL ID OF THE CORRESPONDING AUTHOR:

Dr. Krup Vasavda,
Sai Smriti, 188/1, Sector 2 B, Gandhinagar, Gujarat, India.
E-mail: krup1881@gmail.com

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