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ASSESSMENT OF ADULTERATION IN DIFFERENT MARKETED BRANDS OF COMMONLY USED PESTICIDES IN BANGLADESH

Samina Jahan[1*], Mohammad Dalower Hossain Prodhan[1], Marina Afroze[1] and Nirmal Kumar Dutta[1]

[1]Pesticide Analytical Laboratory, Entomology Division, Bangladesh Agricultural Research Institute, Gazipur 1701, Bangladesh

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ABSTRACT

Pesticide adulteration is extremely harmful for agricultural production and also detrimental to the environment. This study was carried out to investigate the adulteration of the available marketed brands of five selected pesticide groups collected from different dealers in Kishoreganj, Gazipur, and Dhaka. High Performance Liquid Chromatography with an ultra violet detector was used to analyze the pesticides at the Pesticide Analytical Laboratory of Entomology Division, Bangladesh Agricultural Research Institute. Results revealed that 45% of tested pesticides contained lower levels of active ingredients than those specified on the product containers/labels. Of the 68 pesticide brands tested, 37 (approximately 54%) revealed 100% presence of active ingredient (AI), 15 brands had between 80% and 98% of active ingredient (AI), while the remaining 16 brands contain less than 80% active ingredient (AI) as per product labels. Among these, one brand contained no active ingredient of concerned.

Keywords: Assessment, Pesticides, Adulteration, HPLC, Active ingredient

INTRODUCTION

Since the strategies of agriculture and pest management are continuously changing, the use of pesticides has become necessary to maintain sustainable crop yields and protect food supplies worldwide (Singh 2024). Several factors, like changes in cropping patterns and the global population growth, are responsible for the subtle trends in pesticide usage, trade, and indicators around the world (Wisnujati *et al.* 2023). In 2023, the usage of agricultural pesticides reached 3.73 million tons of

*Corresponding author: *saminajahan73@gmail.com*

active ingredients, indicating a 14 percent increase over the past decade and nearly a twofold rise since 1990 (FAO 2025). The widespread use of pesticides has become a pivotal part of agriculture in developing countries like Bangladesh to reduce pest infestations and maximize crop yields (Bhuiya *et al*. 2024). Hence, farmers are spraying chemical pesticides extensively and injudiciously. In Bangladesh, the adulteration of pesticides is considered a major factor contributing to the excessive use of these chemicals. According to a report by the FAO, the average pesticide usage in Bangladesh is approximately 1.80 kg per hectare of land. The total consumption of pesticides in the country in 2022 was around 15,500 tons of active ingredients (FAO 2024).

Pesticide adulteration is not only responsible for reducing crop yields but also leads to the development of resistance in pests to the pesticides used. Impure or adulterated pesticides leave unacceptable residues on crops and the environment at a higher level that exceeds permissible limits, posing threats to human health and ecosystems (Hasan *et al*. 2024). Adulteration of pesticides may occur during various stages of active ingredient (AI) manufacture, particularly when substandard raw materials and low-quality solvents are used, often due to avoidance of necessary purification processes (Bayoumi 2021). Adulteration of pesticides is a serious issue in Bangladesh, as studies indicating numerous pesticide brands contain fewer active substances than specified.

Afroze *et al*. (2021) conducted a study to determine the purity of eleven pesticides using GC and HPLC and reported that 40% of the tested brands contain lower active ingredients than stated on the package/container label. The selected brands of acephate, carbofuran, diazinon, dimethoate, chlorpyrifos, quinalphos, malathion, carbosulfan, cypermethrin, fenvalerate and fenitrothion were collected from Rajshahi, Rangpur, Jamalpur, Bogura, Cumilla, Jashore and Gazipour. In another study, Begum *et al*. (2016) tested the adulteration of several brands of marketed pesticide groups viz., chlorpyriphos, diazinon, carbofuran, pyrazosulfuron ethyl, dimethoate, cypermethrin, carbendazim, mancozeb and quinalphos which were purchased from local dealers of Dinajpur, Rangpur, Rajshahi, Bogura, Jashore, Cumilla, Mymensingh and Narsingdi districts. This study revealed that more than 66% of the tested pesticides had a purity of over 90% as per active ingredients mentioned, 12% had a purity of between 80% and 90%, and the remaining 22%

had a purity of less than 80%. Notably, three brands contained no active ingredients (AI) of the specified pesticides. Another study by Kabir *et al*. (2008) found that most of the marketed pesticides had lower active ingredients (AI), specifically ≤60%, than those mentioned on the labels of the containers. They tested several brands of Carbofuran, Carbaryl, Carbosulfan, Malathion, Diazinon, Cypermethrin, Quinalphos, Dimethoate and Chlorpyrifos.

The FAO Corporate Document Repository indicates that the regulatory framework for pesticide registration is systematic. But in practice, there exist gaps between policies and their implementation. In Bangladesh, pesticide regulation is primarily governed by the Pesticide Act (2018), and Pesticide Rules (2020), which provide strict guidelines for the import, formulation, packaging, labeling, and sale of pesticides. However, the lack of adequate facilities and trained analysts hinders effective monitoring. The pesticide markets in Bangladesh are growing more rapidly than the capacity of regulatory monitoring. Unfortunately, the increase in generic brands, combined with inadequate regulatory enforcement in markets, has led to a significant rise in substandard pesticides. Hence, the quality control of pesticides is essential for ensuring their efficacy, overall quality, and safe application. From this perspective, this study aims to conduct a comprehensive purity analysis of different brands of marketed pesticides in Bangladesh and to ensure their effective, safer, and non-hazardous use.

MATERIALS AND METHODS

Pesticides from five groups were investigated to determine the percentage of active ingredient namely, carbofuran, carbendazim, imidacloprid, emamectin benzoate and thiamethoxam. Various brands of those tested groups were obtained from several dealers of Kishoreganj, Gazipur and Dhaka in the year of 2024 and 2025. The brands were chosen based on their availability in the selected regions and preferences to the farmers. Each container/packet was labeled with an alphanumeric code to identify the location of purchase, active ingredient and the specific brands of pesticides. All formulated products whether granular, powder or liquid were dissolved in the corresponding solvents. Those solvents were selected according to the criteria described by Lehotay and Mastovska (2004).

The pesticide solutions from various brands were prepared following the procedure aligned with the particular instruments in the pesticide analytical laboratory of Entomology Division, Bangladesh Agricultural Research Institute. The solid inert materials were removed through filtration process in case of powder or granular formulations. For liquid pesticides, the solutions were prepared directly at the known concentrations. High-performance liquid chromatography (HPLC) is a commonly used method for assessing the active ingredients of plant protection products. Here, the protocols for testing various brands using HPLC-UV were developed by optimizing the instrument parameters to analyze concerned pesticide groups, which were selected based on the peak sharpness of the chromatogram and retention time of each compound. The instrument parameters of HPLC-20A prominence set for analysis of each group of pesticide are listed below (Table 1):

Table 1. The instrument parameters of HPLC-20A prominence set for analysis of the selected pesticide groups

Pesticide group	Solvent	Detector	Pump mode	Mobile phase	Flow rate	Injec-tor	Inj. vol.
Carbofuran	Methanol	UV detector	Binary gradient	Methanol/water =80/20 (v/v)	1ml/min	Auto	20 µL
Carbendazim	Methanol	UV detector	Binary gradient	Methanol/water =80/20 (v/v)	1ml/min	Auto	20 µL
Imidacloprid	Acetonitrile	UV detector	Binary gradient	Acetonitrile / water=70/30 (v/v)	1ml/min	Auto	20 µL
Emamectin benzoate	Acetonitrile	UV detector	Binary gradient	Acetonitrile / water=70/30 (v/v)	1ml/min	Auto	20 µL
Thiamethoxam	Acetonitrile	UV detector	Binary gradient	Acetonitrile / water=70/30 (v/v)	1ml/min	Auto	20 µL

Quantitative analysis of some common pesticides: Following the injection, data were obtained and analyzed using the concerned instrument i.e., HPLC. The quantity of the active substance present in each brand was determined by comparing with standard solution of corresponding pesticide group through the built-in software of HPLC (LC solution). The purity percentage was calculated by comparing the actual amount of active ingredients (AI) found in various brands to the amount of AI specified for the respective pesticides, using the following formula:

$$\text{Percent of purity} = \frac{\text{Actual amount of AI present in the pesticide}}{\text{Amount of AI recommended /required}} \times 100$$

RESULTS AND DISCUSSION

Carbofuran: Carbofuran is a highly toxic, broad-spectrum carbamate insecticide. Bangladesh has banned the carbofuran pesticide group since 2023, but some brands are still available in markets. While collecting samples, eight brands of carbofuran were found in the selected areas. Those brands of carbofuran 5G and 3G were tested with HPLC-20A Prominance using UV detector. Table 2 shows the amount of active ingredients and their purity percentages in the formulated pesticides.

Table 2. Percentage of Active Ingredient presents in some marketed brands of Carbofuran 5G and 3G

SL No.	Code	Formulation	Amount of AI found (G)	Purity (%)
1.	CfDhKd	3 G	2.22	74
2.	CfDhSr	5 G	2.65	53
3.	CfKiFr	3 G	3	100
4.	CfGaBf	5 G	5	100
5.	CfGaSf	5 G	3.3	66
6.	CfDhCf	5 G	1.4	28
7.	CfDhSf	5 G	5	00
8.	CfGaGf	5 G	3.35	67

The purity levels of the tested carbofuran brands range from 28% to 100%. Notably, one brand did not contain any active ingredients for carbofuran. Out of the eight brands tested, only two had an active ingredient concentration of 100%, four brands had concentrations above 50%, and one brand had AI of 28%.

Carbendazim: Carbendazim is a broad-spectrum, systemic fungicide popularly used in agriculture, forestry, and veterinary medicine to control fungal diseases. The purity of the tested brands of carbendazim was 50% to 100% in terms of AI. Among the fourteen brands, eight contained 100% AI, and the other brands had AI ranging from 50 to 94% purity. The amount of active ingredients found in the formulated pesticides, along with their purity percentages are shown in Table 3.

Table 3. Percentage of Active Ingredient present in the selected marketed brands of Carbendazim 50 WDG, 50 WP and 75 WP

SL No.	Code	Formulation	Amount of AI found (WDG, WP)	Purity %
1.	CdDhAt	50 WDG	50	100
2.	CdDhKn	50 WP	50	100
3.	CdKiSz	50 WP	43.5	87
4.	CdKiKb	50 WP	38.5	77
5.	CdKiDz	50 WP	50	100
6.	CdGaAc	50 WP	50	100
7.	CdGaTb	50 WP	47	94
8.	CdDhAn	50 WDG	50	100
9.	CdDhMn	75 WP (Carbendazim-12%)	10.8	90
10.	CdDhSz	50 WP	50	100
11.	CdGaRd	50 WP	46	92
12.	CdGaAt	50 WDG	50	100
13.	CdGaKn	50 WP	25	50
14.	CdKiBd	50 WP	50	100

The result revealed that out of fourteen tested brands about 58% i.e., eight brands were 100% pure in terms of AI presence. Three brands CdDhMn, CdGaRd and CdGaTb contained above 90% AI while the other three brands CdKiSz, CdKiKb and CdGaKn are 87%, 77% and 50% pure in terms of AI presence.

Imidacloprid: Imidacloprid is a systemic neonicotinoid insecticide which is a class of neuro-active insecticides modeled after nicotine. The purity of the tested brands of imidacloprid was 70% to 100% excluding two brands which contain <50% of AI. Among the twenty brands, twelve contained 100% and the other brands contained AI between <50% to 98%. Table 4 represents the amount of active ingredients as well as their respective purity percentages in the formulated pesticides.

Emamectin benzoate: Emamectin benzoate is a selective insecticide derived from the avermectin compounds. Eighteen popular brands of emamectin benzoate were tested using HPLC-UV. The purity percentages of different marketed brands of emamectin benzoate are shown in Table 5.

Table 4. Percentage of Active Ingredient present in the selected marketed brands of Imidacloprid 20SL, 70WG, 80 WDG and 57.5 WDG

SL No.	Code	Formulation	Amount of AI found (SL, WG, WDG)	Purity %
1.	ImDhEt	20 SL	20	100
2.	ImDhEp	20 SL	17.2	86
3.	ImDhPr	20 SL	14	70
4.	ImGaAd	20 SL	20	100
5.	ImGaTd	20 SL	20	100
6.	ImKiEt	20 SL	20	100
7.	ImKiMk	70WG	31.5	45
8.	ImKiCf	70WG	70	100
9.	ImDhAp	20 SL	20	100
10.	ImDhImx	20 SL	18.2	91
11.	ImDhIt	20 SL	20	100
12.	ImDhTd	20 SL	20	100
13.	ImGaSc	20 SL	19.6	98
14.	ImGaIt	20 SL	20	100
15.	ImGaRp	20 SL	14.4	72
16.	ImKiIt	20 SL	20	100
17.	ImKiTc	80 WDG (Imidacloprid-40%)	40	100
18.	ImKiTg	57.5 WDG (Imidacloprid-52.5%)	52.5	100
19.	ImKiTr	20 SL	6.2	31
20.	ImKiAd	20 SL	16.8	84

In case of 20 tested brands of imidacloprid, apart from twelve brands that contained 100% AI, two brands i.e., ImDhImx and ImGaSc, showed purity over 90%. Four brands namely ImDhPr, ImGaRp, ImKiAd and ImDhEp contained 70% to 86% of active ingredients while the remaining two brands ImKiMk and ImKiTr contained 45% and 31% AI respectively.

Table 5. Percentage of Active Ingredient present in some marketed brands of Emamectin benzoate 5 SG, 10 SG, 10 WDG, 75 WDG and 5 WDG

SL No.	Code	Formulation	Amount of AI found (SG, WDG)	Purity %
1.	EBDhPc	5 SG	5	100
2.	EBDhLv	10 SG	10	100
3.	EBDhSp	5 SG	4.1	82
4.	EBKiJm	5 SG	5	100
5.	EBKiWd	5 WG	3.9	78
6.	EBKiHu	10 WDG	7.5	75
7.	EBKiWb	5 SG	3.4	67
8.	EBGaMD	5 WDG	5	100
9.	EBGaEc	5 WDG	4.3	86
10.	EBGaPt	5 SG	5	100
11.	EBDhAr	5 SG	3	60
12.	EBDhJm	5 SG	5	100
13.	EBDhSd	5 SG	4.6	92
14.	EBGaPr	5 SG	5	100
15.	EBGaBz	75 WDG (EB-5%)	4.15	83
16.	EBKiTg	5 WDG	5	100
17.	EBKiSp	5 WDG	5	100
18.	EBKiGm	5 SG	4.8	96

Analysis results of emamectin benzoate revealed that nine of the tested brands were 100% pure in terms of AI presence. Two brands EBDhSd and EBKiGm contained above 90% AI, while five brands contained AI between 75% to 86%. The remaining two brands EBKiWb and EBDhAr were 67% and 60% pure, respectively in terms of AI presence.

Thiamethoxam: Thiamethoxam is a widely used neonicotinoid insecticide having systemic, contact, and stomach action against a broad spectrum of pests. Eight brands of thiamethoxam were collected and analyzed for adulteration using HPLC-UV. The purity percentages and active ingredient concentrations of different marketed thiamethoxam brands are presented in Table 6.

Table 6. Percentage of Active Ingredient presents in some marketed brands of Thiamethoxam 25 WG, 70 WS and 40 WDG

SL No.	Code	Formulation	Amount of AI found (WG, WS, WDG)	Purity %
1.	TmDhAt	25 WG	25	100
2.	TmKiCr	70 WS	70	100
3.	TmKiMm	25 WG	24.3	97
4.	TmGaCr	70 WS	70	100
5.	ThDhAc	25 WG	25	100
6.	ThGaAc	25 WG	25	100
7.	ThDhCr	70 WS	70	100
8.	ThKiAb	40 WDG (Thiamethoxam-20%)	19.2	96

In case of thiamethoxam, among the eight tested brands, six brands TmDhAt, TmKiCr, TmGaC, ThDhAc, ThGaAc and ThDhCr showed 100% presence of AI, whereas the other two brands TmKiMm and ThKiAb were 97% and 96% pure, respectively in terms of AI presence.

The farmers in Bangladesh are traditionally using synthetic pesticides to protect crops from insect pests' infestation and to maximize yield on the limited arable land. Due to adulteration, pesticides do not perform effectively in the field and numerous pests are becoming resistance to pesticides (Begum *et al*. 2016). Tahir *et al*. (2024) reported that of pesticide resistance across numerous pest species often increases up to 25,000 times and resistance to one pesticide can leads to cross resistance to other unrelated pesticides. This growing resistance compels farmers to either increase pesticide doses and frequency, or move to more powerful, sometimes more environmentally persistent alternatives. Moreover, the destruction of natural predators through pesticide application can lead to pest resurgence and secondary pest outbreaks. These phenomena often result in a vicious cycle of increased pesticide application, which leads to the presence of pesticide residues in various agricultural commodities, as reported by researchers in Bangladesh (Paul *et al*. 2025, Ahmed *et al*. 2024, Alam *et al*. 2023, Alam *et al*. 2022, Hasan *et al*. 2021, Islam *et al*. 2021, Nisha *et al*. 2021, Parven *et al*. 2021, Parvin *et al*. 2021, Prodhan *et al*. 2021, Nahar *et al*. 2020, Islam *et al*. 2019, Islam *et al*. 2019a, Islam *et al*. 2019b, Rahman *et al.* 2019, Prodhan *et al*. 2018, Prodhan *et al*. 2018a, Prodhan *et al*. 2018b).

The extensive use of adulterated pesticides unintentionally destroys beneficial organisms, like pollinators and predators, thereby disrupting biodiversity and ecological balance (Lengai and Muthomi 2018). Besides, a significant amount of capital is also spent for purchasing pesticides (Afroze *et al*. 2021). In addition, the lower active material concentrations in marketed pesticides and their residues have raised concerns regarding their potential adverse effects on human health and the environment (Beyuo *et al*. 2024). These residues can lead to acute and chronic toxicities, including immediate neurotoxic effects such as headaches and respiratory disorders, as well as long-term health problems (Ahmad *et al*. 2024, Carreiró *et al*. 2025). Chronic exposure has been associated with higher risks of cancer like non-Hodgkin lymphoma, Parkinson's disease, and endocrine disruption (Beyuo *et al*. 2024, Zhou *et al*. 2025). Infants and pregnant women are more vulnerable to these threats. On the other hand, residues of these adulterated pesticides also resulted in significant environmental degradation along with soil contamination and aquatic ecosystem disruption. These residues additionally facilitate the bioaccumulation and biomagnification of persistent organic pollutants within food chains (Munir *et al*. 2024, Osaili *et al*. 2022).

CONCLUSION

Pesticides play an essential role in the present food production systems, serving as indispensable means to protect crops from pests, diseases, and weeds. So, quality control of marketed pesticides is crucial to ensure safe and effective pesticide usage in agriculture. The study result indicates that, around 45% of tested pesticides contained lower active ingredients than specified on the product labels. From the present study, it is recommended that, before pesticides are authorized for use in the market, they should undergo a quality assessment to identify whether there is actual amount of AI present or not. In addition, this study highlights the importance of rigorous monitoring and adulteration testing of marketed pesticides.

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