Open Access
J. Glob. Innov. Agric. Sci., 2025, 13(1):139-147
ISSN (Online): 2788-4546; ISSN (Print):2788-4538
DOI: https://doi.org/10.22194/JGIAS/25.1463
http://www.jgiass.com

FTIR Analysis of Pesticide Active Ingredients into Seasonal Vegetables: Ensuring Food Safety and Raising Awareness

Md. Mejbah Uddin Mithu[1,3], Sadia Akter Shormela[2,3], Md. Shahinul Islam[1] and Mahfuza Mubarak[2,3*]

[1]Department of Public Health, Daffodil International University, Savar, Dhaka, Bangladesh; [2]Department of Public Health & Informatics, Jahangirnagar University, Savar, Dhaka, Bangladesh;[3]Wazed Miah Science Research Centre (WMSRC), Jahangirnagar University, Savar, Dhaka, Bangladesh.
*Corresponding author's e-mail: mahfuza@juniv.edu

Bangladesh's agriculture sector heavily relies on the use of pesticides for pest control and production. However, improper use and unsafe handling practices can lead to the bio-accumulation of pesticide active ingredients in vegetables, causing high farmer exposure and adverse health effects. This study aimed to detect the presence of pesticide active ingredients in raw vegetables using Infrared Spectroscopy (IR). The study involved four fruit vegetables (Eggplants, Tomatoes, Bitter gourd, Green-bean) and 11 different pesticides used by farmers. The results showed that the most widely applied pesticides were moderately toxic WHO class II pesticides. Organophosphate, Neonicotinoid, and fungicide were found in fruits vegetables (Green bean, bitter gourd & eggplant). Food contamination is a serious concern for developing countries, including Bangladesh. Improper pesticide application can lead to a buildup of agrochemical active ingredients on plants' edible portions, potentially absorbing into the food chain. Programs like farmer's field school, integrated pest management, and the department of agricultural extension's awareness program can help enhance knowledge about effective pesticide usage and prevent health issues related to personal health and safety. It is crucial to limit and avoid misuse and overdose of pesticides in vegetables to prevent the distribution of pesticide molecules and prevent acute and chronic health complications.
Keywords: Vegetable, pesticides, pesticides poisoning, food safety, pesticides residue.

INTRODUCTION

By 2050, there will be an estimated 9 billion people on the planet, making the availability and accessibility of food more important challenges. Pesticides can assist decrease yield losses caused by pests (e.g., insect pests, diseases, weeds) and feed the world's growing population (Ali *et al*., 2020). Agriculture is commonly referred to as farming; it is an art and science that prudently endeavors to modify a portion of the Earth's crust via cultivation of plants and other crops as well as animal breeding for food or other requirements for human beings and economic benefit (Ismail, 2021). Agriculture is recognized as the backbone of the economy of emerging countries and has a substantial economic influence. Essential food crops have always been produced through agriculture. Other phrases that might be used to describe it include distribution, marketing, processing, and promotion of products made from crops and livestock. Modern farming increasingly requires the use of pesticides, which also significantly boosts agricultural output. But one of the biggest environmental and public health issues in the world today is the widespread and indiscriminate use of pesticides (Jallow *et al*., 2017). Bangladesh has fed over 2.15% of the world's population with only 0.102% of the world's arable land. Pesticides enhance Bangladesh's food self-sufficiency by preventing pests from damaging crops. As part of the IAEA's agrochemical residues project, a survey of pesticide use in Bangladesh was done. We discovered that total pesticide usage has increased over the last six years. Insecticides accounted up more over 95% of all pesticides used on agricultural crops, with fungicides, weedicides, and rodenticides accounting for the remaining 5%. Organophosphorus chemicals accounted for 60.4%, carbamates 28.6%, organochlorines 7.6%, and others 3.4% of all pesticides. Pesticides that were used the least were proven to be the most harmful to the environment (Rahman *et al*., 1995) . The research aims to evaluate the level of pesticide use among farmers in Bangladesh and the results indicated that 50.5% of the 321 pesticide brands submitted were registered, 47.7% were unregistered, and 1.9% were

Mithu, M.M.U., S.A. Shormela, M.S. Islam and M. Mubarak. 2025. FTIR Analysis of Pesticide Active Ingredients into Seasonal Vegetables: Ensuring Food Safety and Raising Awareness. Journal of Global Innovations in Agricultural Sciences 13:139-147.
[Received 18 Jul 2024; Accepted 20 Dec 2024; Published 1 Jan 2025]

prohibited. According to the World Health Organization classification system, 5.6% of registered pesticides were very dangerous, 24.8% were moderately toxic, and 6.2% were mildly hazardous. A large majority (96%) of farmers reported using pesticides in their crops, with 16.6% using pesticides more than five times during a cropping season (Zabed Hossain *et al*., 2024). The sustainable development of the pesticide industry is essential to the sustainability of agriculture and has important practical significance (BCPABD, 2022). However, efforts to achieve optimal agricultural production are still hindered by several limiting factors, including water scarcity, climate change, and plant pests and diseases. Most of the Indonesia's population derives a significant portion of its income and economic growth from the agricultural sector (Avelia Sandy *et al*., 2024)

The human body is made up of many parts that work together to carry out certain functions, which, in turn, involve keeping the body alive. The human body could be the finest machine on Earth. Even though the human body is a massive and vital mechanism, many individuals have made this comparison (Wakim and Grewal, 2021) . The human body, like a machine, needs fuel to function and operate. The body's fuel is food. Generally, two types of food such as animal foods & vegetable foods are required for the human body. Vegetables are a major part of diet contributing nutrients mainly, vitamins and minerals. On 470,414 hectares of fertile land in Bangladesh, more than 60 different indoor and outdoor vegetable species are cultivated at a 2.8% annual growth rate (Faleiro *et al*., 2023) . Pesticides are a chemical danger related with food contamination, and the contamination of food by chemicals, in particular pesticides, is a serious public health problem now a days (Begum *et al*., 2019) . In Bangladeshi agriculture, there are over 80 varieties of registered pesticides with 170 distinct trade names (Begum *et al*., 2013) .

Plants can absorb pesticides through their leaves and roots. Pesticides that are absorbed by plants can spread to other tissues of the plant (translocate) (Afif *et al*., 2021). This is a result of most farmers' misunderstanding about the harmful effects of pesticide overuse. Vegetables with pesticide residues have been demonstrated to be harmful to human health, especially when they are eaten raw (Akomea-Frempong *et al*., 2017) . Pesticide exposure affects everyone, but farmers and agricultural workers are more vulnerable to pesticide exposure due to the extra risk of occupational exposure (Ali *et al*., 2020).Pesticide residues have both short- and long-term toxic effects that are harmful to one's health, particularly at greater levels where toxicity can occur. Acute pesticide exposure has been linked to headaches, nausea, irritation, vomiting, diarrhea, abdominal discomfort, and hypersensitivity. Chronic pesticide exposure also raises the risk of birth abnormalities, neurological diseases, organ damage (kidney/liver), mutagenic and carcinogenic changes, and endocrine disruption. Because of their small bodies, undeveloped immune systems, and fast development cycles, children are more vulnerable, particularly in the brain and neurological systems (Begum *et al*., 2019)Those who are immediately exposed to pesticides are the most vulnerable. This includes agricultural workers who apply pesticides as well as anybody else in the immediate vicinity when chemicals are dispersed. A pesticide's toxicity is determined by its function and other aspects. Toxicity can be determined by the method of exposure, such as swallowing, breathing, or direct skin contact (WHO, 2022). Farmers in Bangladesh are excessively using pesticides due to ignorance of their risks, recommended dosages, and standardized regulations. This issue is exacerbated by the country's expanding irrigated agriculture, which uses around 80 registered pesticides with 170 trade names. The lack of awareness and knowledge about pesticide hazards contributes to misconceptions and overuse, negatively impacting vegetable output. Factors contributing to pesticide exposure include financial underdevelopment, lack of reading skills, lack of extension officers, and a lack of understanding of personal protective equipment (PPE). Pesticide exposure leads to long-term health impacts, including carcinogenic and endocrine-disrupting qualities. Insufficient knowledge, improper storage, negative attitudes, and inappropriate practices contribute to the morbidity and mortality of pesticide exposure (Begum *et al*., 2019; Gesesew *et al*., 2016; Hasan and Rahman, 2019; Shammi *et al*., 2020). Pesticide use is crucial for reducing agricultural pests and improving food production, with an estimated 2.5 million tons used annually worldwide, a growing concern due to global population growth(FAO/WHO, 2011). Pesticides have been associated with a wide range of human health hazards such as headache and nausea to chronic impacts like cancer, Alzheimer's disease and even birth defects. Pesticides also have the potential to damage the nervous, reproductive and the endocrine system (Hasan *et al*., 2014).

Bangladeshi farmers have used 38% more toxic pesticides in agricultural areas between 1997 and 2008, posing risks to human and environmental health due to long-term residual effects. This increase has been significant since 2000 (Shariful Islam, 2016). (Sooman and Macintyre, 1995) found pesticide residues in food can cause cancer, teratogenesis, genetic damage, and immune suppression, resulting in 20,000 deaths annually in underdeveloped nations. Pesticides directly affect the brain and peripheral nervous system, with all types potentially impacting brain and neural tissue, even if they have no visible effects (Kesavachandran *et al*., 2009). Adverse Health Effects of Pesticides in Agrarian 45 The reproductive toxicity data from couples spraying organochlorine, organophosphorus, and carbamate pesticides in cotton fields demonstrate impaired reproductive performance (Kesavachandran *et al*., 2009).

Due to the severity of its effects, the use of pesticides on vegetables and its health impact has recently garnered attention. Pesticide usage in accordance with guidelines has always been neglected, and the situation remains unchanged.

Pesticide bio accumulates in vegetables because of farmer ignorance, and it enters the human food chain. Now is the moment to raise awareness to farmers, put them into the forefront of policymaking, and pay some attention to them. These are the things they want, and we must oblige. Bangladesh's agricultural sector, which contributed 60% of the country's GDP, has seen a decline in recent years, from 17.6% in 2010 to 12.6% in 2020. Despite this, the sector has maintained profitability and productivity despite population growth and the effects of the pandemic and climate change. Farmers' perceptions and attitudes towards pesticide exposure, lack of education, and inadequate awareness of safe methods contribute to these risks. A National Agricultural Census study found that 55.00% of agricultural laborers have health issues, with respiratory, skin, gastrointestinal, conjunctivitis, arthritis, hypertension, diabetes mellitus, anemia, and hearing loss being the most common (Ahm *et al*., 2022;Tribune, 2019; Jallow *et al*., 2017; Seraj, 2022).

This study aims to detect pesticide use and investigate the presence of active components in vegetables. This study was the first attempt to use FTIR to detect the pesticide active ingredients in different seasonal vegetables. The study will be a scope to ensure food safety, build awareness about the impact of pesticides on human health with farmers and consumers.

MATERIALS AND METHODS

Study area: This study was carried out in near the Naogoan district in Bangladesh, which lies within latitudes from 24° 58' 0.55" N to 24° 57' 49.91"N and longitudes from 89° 5' 4.65"E to 89° 5' 11.76"E which is 500 km long (Fig. 1).

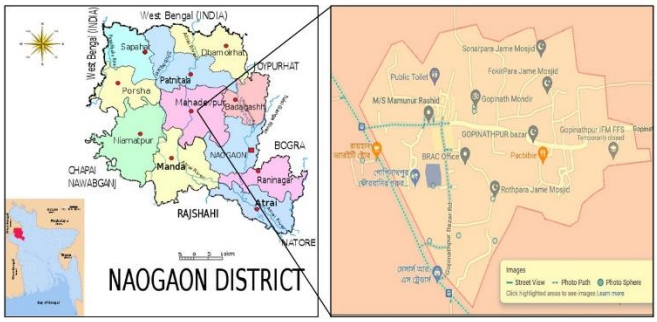

Figure 1. Study area.

***Sample collection*:** Sampling was done during the winter season from December 2021 to January 2022. 0.5 kg of each type of vegetable Eggplant, Bitter gourd, Tomatoes and Been was randomly bought from farmers farming along the sampling sites and put in separate well-labeled bags to indicate the site and date of sampling. after collecting samples, it was kept in lab refrigerator at 2^0C, dept. of Public Health & Informatics, Jahangirnagar University and samples immediately transported to "Wazed Miah Science Research Center" Jahangirnagar University, Savar, Dhaka, Bangladesh for pesticide analysis.

***Sample analysis*:** At the beginning of the sample preparation, necessary equipment like knife, chopping board, marker, scissor, foil paper, Petridis etc. arrange properly as well as label the sample name onto to Petridis. The sample has washed in the basin in running water then it has kept in room temperature until surface water drying. Then with a sharp sterile knife sample was peeled and separated edible part of vegetables. Here we used a microvan to remove moisture from this sample. For this step samples were dried under 70^0C at 13hours unit the moisture removed. With a mortar pestle dried samples are made into powder form and kept into air tied Eppendorf tube for analysis. Then we have to sterilize all the equipment with acetone because of protection of cross contamination. A small amount (0.25g) of potassium bromide (KBr) salt generally one spatula has taken and taken very tiny amount (0.01g) of sample. Then grind it properly with a pestle. After making powder form sample has kept into base die and keep top die on it. Then set the die holder and put it under hydraulic press at 80 pressure and start the rotary vacuum pump for 2 minutes to remove moisture. Then the salt plate took out and packaged it with labeling and kept it in desiccator because of desiccator prohibit to grow moisture. Then the salt plate is set into IR machine (Model no: IRPrestige-21) for analysis.

The sensitivity of Fourier Transform Infrared (FTIR) spectroscopy is limited, especially for detecting very low pesticide doses, despite its usefulness in identifying pesticide residues. Because of the possibility that its detection threshold would be insufficient for extremely diluted samples, it has trouble correctly recognizing trace levels. Furthermore, overlapping spectrum signals can be produced by complicated pesticide mixes, making it challenging to discriminate between different substances. Extensive sample preparation is also necessary for FTIR to reduce interference from other chemicals. Finally, the resolution of the method may be reduced in comparison to more sophisticated approaches like

Table 1. Details information of pesticides.

Sr.	Trade Name	Active component	Physical condition	Company	Country
1	Tido	20 S.L (Imidacloprid)	Liquid	Syngenta	Bangladesh
2	Actara	25 W.G (Thiamrthoxam 25% wg)	Granule	Syngenta	Bangladesh
3	Knowin	50 W.P (Carbendazim 50%)	Powder	Syngenta	Bangladesh
4	Ridomil gold	M.Z 68 W.G (Mancozeb + Metalaxyl)	Granule	Syngenta	Bangladesh
5	Tafgor	40 E.C (Dimethid) / Organophosphate	Liquid	Syngenta	Bangladesh

mass spectrometry, which are more appropriate for trace analysis.

RESULTS

***Green bean*:** Figures 1, 2 and 3 represent the spectrometry of three different pesticides along with sample of green bean. According to the sample (green bean) and pesticide (A) molecule, (B) molecule and (C) molecule atomic structure, the sample green bean contains hydroxyl bond (-OH), carboxylic acid bond (-COOH), C-O bond, C=O bond, C-H Bond C-C single and C=C double bond respectively. On the other hand, pesticide (A- (Mancozeb+Metalaxyl)) chemical structure contains C-O bond, C=O bond, C=C bond, C-H bond and C-N bond. As well as pesticide (B- Carbendazim) molecule chemical structure has C=C bond, C-H bond, C=O bond, C-O bond, N-H bond, C-N bond and C=N bond. Finally, pesticide (C) which is known as Dimethoate also named as Organophosphate that contains C-C bond, C=O bond, N-H bond, C-H bond, C-O bond, C-N bond, P=S bond, P-O bond etc. According to IR spectroscopy table (that is mentioned below) C-N bond IR frequency is between 1020-1230 $cm^{-1}$with medium intensity, C=N bond IR frequency from 1550 $cm^{-1}$to 1650 cm^{-1} and C-H bond IR frequency is from 2700 cm^{-1} to 3300 cm^{-1} with also medium intensity. The common point of the below IR graph is Figure 1 1050 cm^{-1}, 1650 $cm^{-1}$and 2930 cm^{-1} which represents C-N bond, C=N bond and C-H bond respectively. According to figure 2 the common points IR frequency is 1050 cm^{-1}, 1650 cm^{-1} and 2930 cm^{-1}which represents C-N bond, C=N bond and C-H bond respectively. And in the last figure 3 the common point is 1020 cm^{-1} that represents C-N bond and 2930 cm^{-1} wavelength that indicate C-H bond. Though both sample and pesticide contain C-H bond, but C-N bond contains pesticide (1, 2, 3) and C=N bond contains only pesticide (B). Since the IR spectroscopy detects C-N bond and C=N bond in sample (Green bean) so it proves that green bean contains pesticide molecule after harvesting as well as marketing.

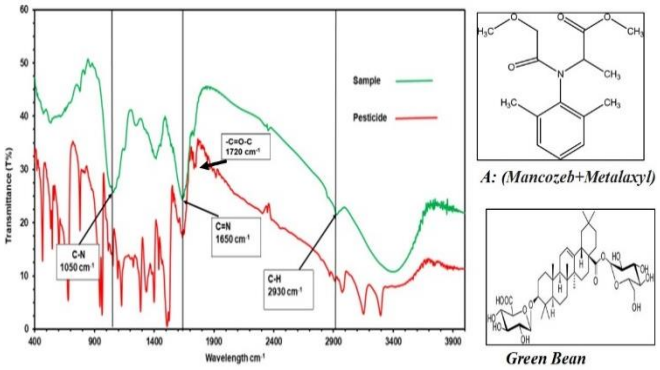

Figure 1. IR spectroscopy of green bean and pesticide A (Mancozeb + Metalaxyl).

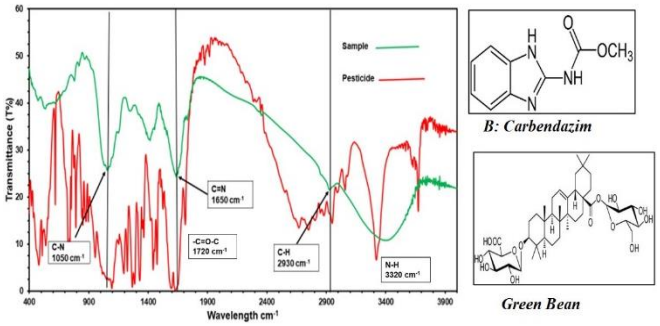

Figure 2. IR spectroscopy of green bean and pesticide B (Carbendazim).

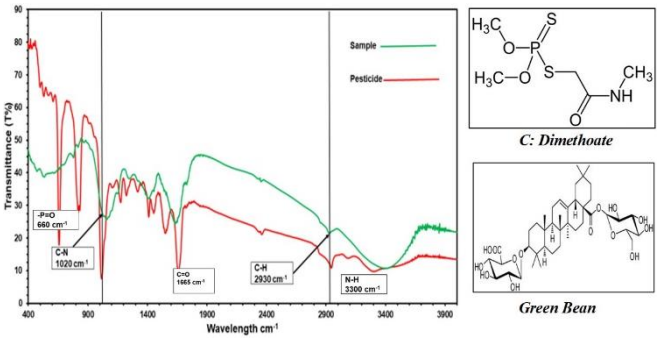

Figure 3. IR spectroscopy of green bean and pesticide C (Dimethoate).

***Bitter gourd*:** The spectrometry of three different pesticides, as well as a sample of bitter gourd, are shown in figures 4, 5 and 6. The hydroxyl bond (-OH), aldehyde bond (-CHO), C-O bond, C-H bond, C-C single bond, and C=C double bond are all present in the sample bitter gourd. Contrarily, the chemical structure of the insecticide (A-(Mancozeb+Metalaxyl)) has C-O, C=O, C=C, C-H, and C-N bonds. The chemical structure of the pesticide (B-Carbendazim) molecule also includes C=C, C-H, C=O, C-O, N-H, C-N, and C=N bonds. The last pesticide is pesticide (D), also known as imidacloprid, which has the following bonds: C-C, C=C, N-H, C-Cl, C-N, C=N, and C-H. According to the IR spectroscopy table that was mentioned previously, the medium intensity C-N bond IR frequency is between 1020 and 1230 cm^{-1}, the C=N bond IR frequency is between 1550 and 1650 cm^{-1}, and the C-H bond IR frequency is between 2700 and 3300 cm^{-1}. Figure 4 contains 1050 cm^{-1}, 1650 cm^{-1}, and 2930 cm^{-1}, which represent the C-N bond, C=N bond, and C-H bond, respectively, are the common points of the IR graph shown below. Figure 5 shows that the common IR frequencies for the C-N bond, C=N bond, and C-H bond are 1050 cm^{-1}, 1650 cm^{-1}, and 2930 cm^{-1}, respectively. And in the last illustration (6), the common points are 1050 cm^{-1}, 1650 cm^{-1}, and 2930 cm^{-1}, which, respectively, stand for C-N bonds, C=N bonds, and C-H bonds. Although the C-H bond is present in both the sample and the pesticide, the C-N bond

includes the pesticides (4, 5, 6) and the C=N bond contains the pesticide (B) (D). The fact that the IR spectroscopy identified the C-N and C=N bonds in the sample (bitter gourd) indicates that the vegetable still contains pesticide molecules after being harvested and marketed.

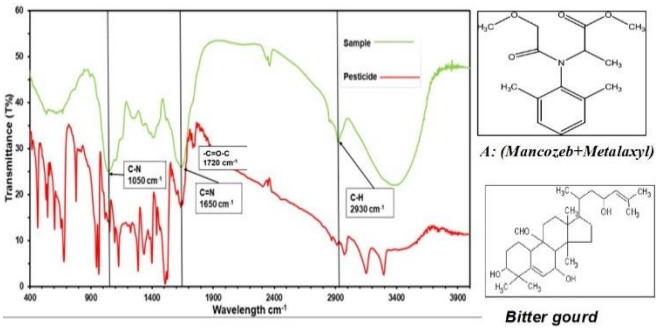

Figure 4. IR spectroscopy of bitter gourd and pesticide A (Mancozeb + Metalaxyl).

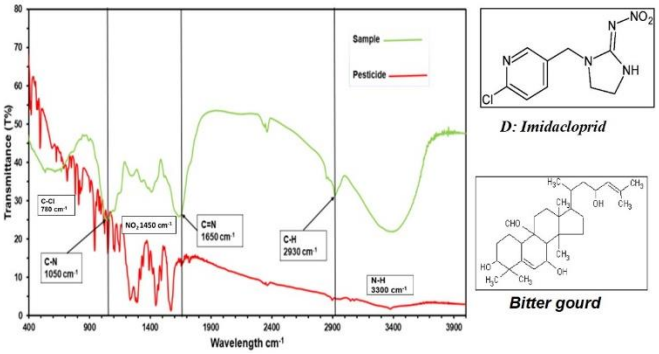

Figure 5. IR spectroscopy of bitter gourd and pesticide D (Imidacloprid).

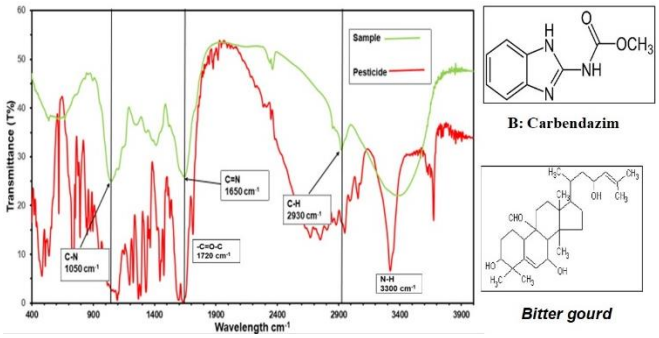

Figure 6. IR spectroscopy of bitter gourd and pesticide B (Carbendazim).

***Tomato*:** The spectroscopy of the sample (a tomato) and pesticide is displayed in the two IR graphs below. Tomato samples and pesticide (B: carbendazim) are shown in Figure 7 and 8. The second picture displays a tomato sample along with the pesticide (A: Mancozeb+Metalaxyl). So first, the sample (a tomato) has some molecular bonding according to its chemical structure. It has C-C bonds, C-O bonds, N-H bonds, -OH bonds, and other bonds. The C-C bond, C-C double bond, C=O bond, C-O bond, C-H bond, and C-N bond are all present in pesticide A at the same time. Additionally, pesticide B, carbendazim, comprises the C-C, C=C, C-N, N-H, C=O, and C-H bonds. Every single bond has a specific wavelength number within a particular range and with a particular intensity. The C-N bond wavelength ranges from 1020 cm^{-1} to 1230 cm^{-1}, the C=N bond wavelength ranges from 1550 cm^{-1} to 1650 cm^{-1}, the C=O bond wavelength ranges from 1715 cm^{-1} to 1745 cm^{-1}, and the C-H bond wavelength ranges from 2700 cm^{-1} to 3300 cm^{-1} with a medium intensity. Three points in the below picture are similar, indicating that the molecules in the sample and the pesticide are same. Here, the typical point wavelengths are 1050 cm^{-1}, 1650 cm^{-1}, 1720 cm^{-1}, and 2920 cm^{-1}. The C-N bond, C=N bond, C=O bond, and C-H bond, respectively, are represented by these points when this wavelength number is compared to a reference table. Even though only the C-H bond carries both the pesticide (A: (Mancozeb+Metalaxyl) & pesticide (B: Carbendazim) & tomato, but the C-N, C=O bond, and C=N bond only contain the pesticide. However, following laboratory extraction, vegetable tomato still contains C-N, C=O, and C=N bonds. However, it demonstrates that even after harvesting and cooking, the pesticide molecule is still present in vegetable tomato.

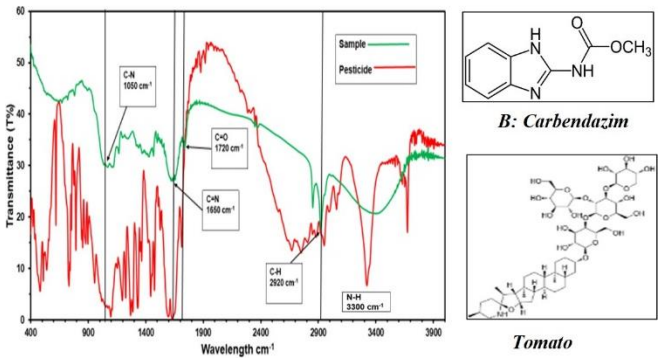

Figure 7. IR spectroscopy of tomato and pesticide B (Carbendazim).

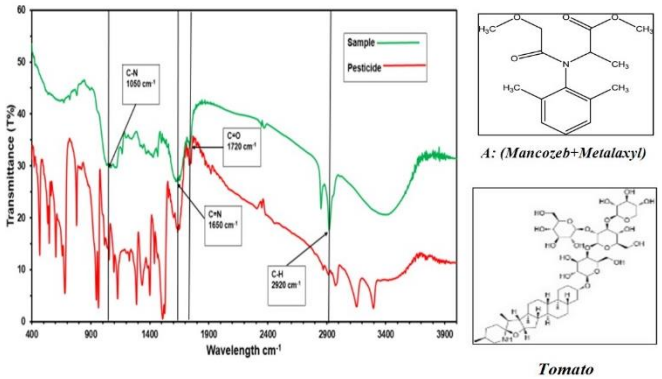

Figure 8. IR spectroscopy of tomato and pesticide A (Mancozeb + Metalaxyl).

***Eggplant*:** Figures 9, 10, and 11 represent that the combine IR spectroscopy of eggplant which marked as sample and three different pesticides like pesticide A as (Mancozeb + Metalaxyl), pesticide B as Carbendazim and pesticide E as Thiamethoxam. All these graphs show some common points of both sample and pesticide and indicate the same molecule contains both sample and pesticide. As pesticides were administered to vegetables during cultivation there is chance to remain pesticide residue in vegetables after harvesting as well as cooking. Eggplant chemical structure shows that there are some bonds in this molecule such as C-C bond, C=C bond, C-O bond, C=O bond, -OH bond. According to IR frequency table, C-Cl bond wavelength number is between 600-800 cm^{-1}, C-N bond IR frequency from 1020 to 1230 cm^{-1}, C=N bond wavenumber is 1550 to 1650 cm^{-1}, and C-H bond wavenumber is between 2700 cm^{-1} to 3300 cm^{-1} with medium intensity. As shown below picture common points wavelength number is 780 cm^{-1} so it like C-Cl bond, 1050 cm^{-1} indicate C-N bond, 1650 cm^{-1}indicate C=N bond and 2930 cm^{-1} similar to C-H bond. Pesticide A contains C-C bond, C=C bond, C-O bond, C=O bond, C-N bond and C-H bond. C-N bond was present after harvesting and cooking though pure eggplant doesn't contain C-N bond. Moreover, Pesticide B contains the following bond: C-C, C=C, C-O, C=O, N-H, C-N, C=N and C-H. Here C-N and C=N bonds are also present in eggplant though sample chemical structure doesn't contain this bond. So, the presence of C-N bond and C=N indicate pesticide B residue still remain after harvesting and cooking. Finally, pesticide E has also numerous chemical bonds. They are C-C bond, C=C bond, C-N bond, C=N bond, C-Cl bond, C-O bond, C-S bond, N-N bond and C-H bond. According to the explanation below, eggplant contain C-Cl bond, C-N bond, C=N bond that are not normally present at pure eggplant. Since eggplant still now contain pesticide chemical bond, so it proves that pesticide residue absorbs vegetables during administration of pesticide in the period of cultivation.

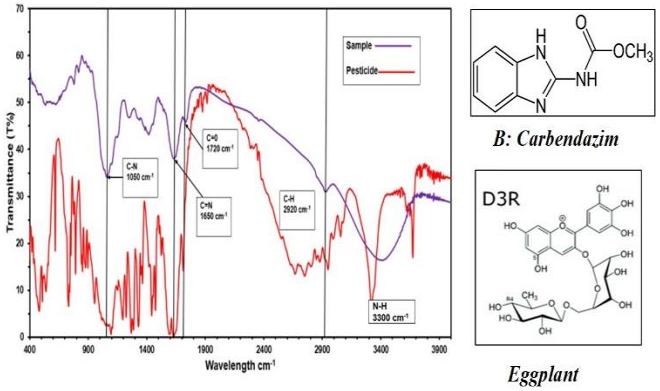

Figure 9. IR spectroscopy of Eggplant and pesticide B (Carbendazim).

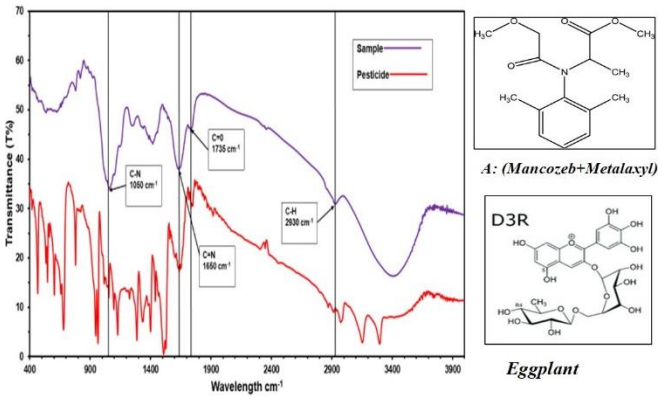

Figure 10. IR spectroscopy of Eggplant and pesticide A (Mancozeb + Metalaxyl).

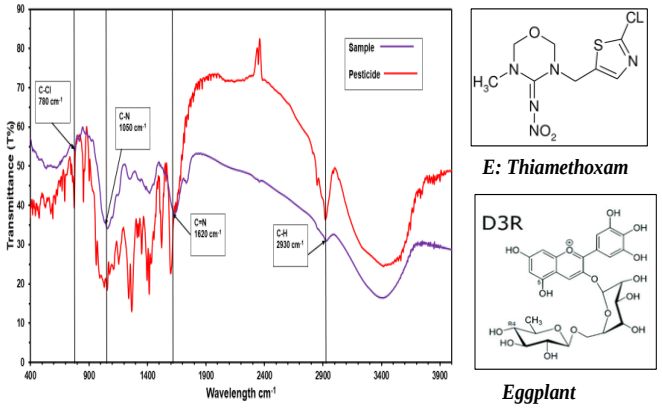

Figure 11. IR spectroscopy of Eggplant and pesticide E (Thiamethoxam).

DISCUSSION

Food and nutrition are one of the vital parameters for a happy, healthy and productive life; however, food and nutrition related disorder do not receive enough attention and are not adequately addressed as a public health issue in countries like Bangladesh. This study conclusively reveals most updated condition of knowledge about pesticide and associated health risk as well as pesticide residue into vegetables after harvesting and marketing at Naogon district in Bangladesh.

In the laboratory study, in our study we use 8 different sessional vegetables. Among these vegetables we found 5 pesticide molecules active components. We found, Tido (active components- Imidacloprid, types-insecticide), Actara (active components-Thiamrthoxam, types-Insecticide), Knowin (active components-Carbendazim, types-Systemic fungicide, Ridomol gold (active components- Mancozeb +Metalaxyl, types- Fungicide) and Targor (active components-Organophosphate, types-Insecticide). The study done by (Dinede *et al*., 2023) found that 25% of Swiss chard samples, 13% of cabbages, and 50% of tomatoes had two or

more pesticides, with diazinon, propargite, and profenofos showing residual values over the EU MRL.

Significant health concerns are associated with the presence of pesticide residues in food and water, especially for vulnerable groups including children and expectant mothers. Long-term exposure to pesticide residues has been connected to several health concerns, including as cancer, neurological conditions, and endocrine disruption, which can cause delays in development and reproductive abnormalities (Gupta, 2022) . Furthermore, it is well recognized that pesticides like organophosphates affect the neural system over time and decrease cognitive function, raising the likelihood of neurodegenerative illnesses like Parkinson's (Hussain, 2022). Stricter regulations are desperately needed, as pesticides are widely used in agriculture, particularly in low- and middle-income nations. To lower the total pesticide load, these laws should include regular monitoring of pesticide levels in food and water, stronger enforcement of safe application techniques, and the promotion of sustainable agriculture alternatives.

These pesticides are classified as toxicity class II according to WHO. Toxicity class II means these are moderately hazardous. Into Green bean vegetables we found two fungicides and one insecticide type pesticide they are Ridomil gold, Knowin and Tafgor. Tido, knowin and Ridomil gold are found in bitter gourd vegetables. The study found that consumption of certain pesticides, such as lambda-cyhalothrin, fipronil, dimothoate, and omethoate, at doses of 0.1 and 0.2 kg day^{-1}, may lead to acute or chronic hazards in spinach, zucchini, kaki, and strawberries (El-Sheikh *et al*., 2022) . The study found that 1.0% of samples had residues above the Korean maximum residue level, with 32 types of pesticide residues, with chlorfenapyr, procymidone, etofenprox, pendimethalin, fluopyram, and azoxystrobin being the most common (Kyu Park *et al*., 2022) Tido is insecticide type pesticide and knowin & Ridomil gold is systemic fungicide pesticide. Into Indian spinach vegetables, we found Actara, knowin and Ridomil gold pesticide where actara is insecticide type pesticide rest two pesticide are fungicide type. Tafgor which is considered as organophosphate is found into spinach and it is insecticide type pesticide. Moreover, two fungicide type pesticide are found in spinach vegetables. Only Knowin pesticide found in steam amaranth. Two different types of fungicide are found in tomatoes such as knowin and Ridomil gold. Both insecticide and fungicide type pesticide are found in eggplant vegetables. Actara which is insecticide types and Knowin, Ridomil gold fungicide type pesticide is found into eggplant. Finally, two types of fungicide are found in carrots such as Ridomil gold and Knowin. Individual pesticide residue levels in vegetables varied from 0.007 to 0.037 mg/kg on average. Cypermethrin, difenoconazole, and fenobucarb were discovered most frequently (72%, 41%, and 37%, respectively) among the 10 target pesticides (Nguyen Dang Giang *et al*., 2022). This study calculated the dietary risk associated with the presence of 22 pesticide residues in vegetables sold at supermarkets and farmers markets in Chile and Mexico. In chard, lettuce, green chili, tomato, and spinach, 11 pesticide residues were measured, including carbaryl, carbofuran, chlorothalonil, chlorpyrifos, cypermethrin, dimethoate, endosulfan alpha, endosulfan sulfate, lambda-cyhalothrin, and monocrotophos (Calderon *et al*., 2022) .The study's findings show that farmers' knowledge levels are lacking, and this is apparent in their behavior. Continuous pesticide safety training should be provided to farmers, together with education on how to wear personal protection equipment, practice excellent personal hygiene, and keep their surroundings tidy both before and after using pesticides. It is also possible to start promoting alternative pest management methods like the usage of bio insecticides. Chemical pesticides would be less essential due to their harmful impacts on both human health and the environment. The inherent sensitivity limitations of FTIR spectroscopy, which may not detect very low levels of pesticide residues, could lead to false positives or negatives in this study. Furthermore, the intricacy of sample preparation may introduce impurities or compromise the precision of the findings. These factors highlight the need for complementary methods, such as mass spectrometry, to improve detection precision.

***Conclusion*:** Food contamination is a significant challenge for developing countries like Bangladesh, as it contributes to non-communicable diseases (NCDs) and other communicable diseases. Farmers in Gupinathpur lack proper knowledge about pesticide usage, leading to unsafe practices. Multiple pesticide is present in single vegetables that are identified by this research. The most widely utilized agrochemicals in the research region were WHO class II pesticides. Initiatives to improve farmers' understanding, enforce pesticide sales restrictions, and implement Integrated Pest Management (IPM) can help reduce pesticide use and chemical exposure. The Bangladesh food safety authority's attention to farmers can significantly reduce health issues related to pesticide use and food contamination.

***Authors contributions statement*:** Mithu, M.M.U, Shormela, S.A- conceptualization, designed, writing draft. Islam,M.S, Mubarak,Mahfuza- supervising, reviewed and finalized the manuscript.

***Conflict of interest*:** The authors declared no conflict of interest.

***Acknowledgement*:** We are thankful to Dr. Mahfuza Mubarak for her proper guidance, supervising and co-operation in this report as well as “Wazed Miah Science Research Center” for their continuous cooperation and assistance.

***Funding*:** No external funding is involved in this study.

***Availability of data*:** All data used are within the manuscript.

***Informed consent*:** N/A.
***Consent for publication*:** All authors submitted consent to publish this article.
***SDGs addressed*:** Zero Hunger, Good Health and Well-Being Responsible Production and

REFERENCES

Afif, S., M. Zobir, A. Ali, F. Adzmi, R. Sulaiman and K. Ahmad. 2021. biology A Review on Nanopesticides for Plant Protection Synthesized Using the Supramolecular Chemistry of Layered Hydroxide Hosts A Review on Nanopesticides for Plant Protection Synthesized Using the. https://doi.org/10.3390/biology10111077

Ahm, H., H. Mt, I. Ms and A. Fs. 2022. Common Health Problems Among Agricultural Workers in A Selected Rural Area of Mymensingh, Bangladesh Vol. 11.

Akomea-Frempong, S., I.W. Ofosu, E.D.J Owusu-Ansah and G. Darko. 2017. Health risks due to consumption of pesticides in ready-to-eat vegetables (Salads) in Kumasi, Ghana. International Journal of Food Contamination vol. 4.

Ali, M. P., M.M.M Kabir, S.S. Haque, X. Qin, S. Nasrin, D. Landis, B. Holmquist and N. Ahmed. 2020. Farmer's behavior in pesticide use: Insights study from smallholder and intensive agricultural farms in Bangladesh. Science of The Total Environment 747:141160.

Avelia Sandy, Y., F. Ainuz Zahro, D.D. Ratih Rizky, S. Kusuma Fajarwati and M. Effendi. 2024. Knowledge Level of Farmers regarding the Use of Pesticide for Pest and Disease Control. Jurnal Agrinika: Jurnal Agroteknologi Dan Agribisnis 08:1.

BCPABD. 2022. Importance of pesticide. Pesticide Knowledge Bank.

Begum, M. E. A., M. I. Hossain, and l. d. haese. 2013. Food security in bangladesh: present status and trend. Progressive Agriculture 24:263-271.

Begum, S., S. Sultana, M. S. Ahmed and M. A. K. Azad. 2019. Pesticide Residue Analysis from Winter Vegetables Collected from Six Markets of Rajshahi Bangladesh. Journal of Environmental Sciences & Natural Resources 12:43-50.

Calderon, R., J. García-Hernández, P. Palma, J. B. Leyva-Morales, M. Zambrano-Soria, P.J. Bastidas-Bastidas and M. Godoy. 2022. Assessment of pesticide residues in vegetables commonly consumed in Chile and Mexico: Potential impacts for public health. Journal of Food Composition and Analysis 108:104420.

D. Tribune. 2019. Agricultural-census-report. Dhaka Tribune.

Dinede, G., W. Bihon, L. Gazu, S. F. Mbokou, S. Girma, R. Srinivasan, R. Roothaert, D. Grace, H. Gashaw and T. J. D. Knight-Jones. 2023. Frontiers in Sustainable Food Systems 01 frontiersin.org Assessment of pesticide residues in vegetables produced in central and eastern Ethiopia.

El-Sheikh, E.-S.A., M.M. Ramadan, A.E. El-Sobki, A.A. Shalaby, M.R. Mccoy, I.A. Hamed, M.B. Ashour and B.D. Hammock. 2022. molecules Pesticide Residues in Vegetables and Fruits from Farmer Markets and Associated Dietary Risks.

Faleiro, M.L., S. Islam, H.M. Irfanullah, A. Dewan and A.K.M Shahidullah. 2023. Knowledge, attitude, and practice of pesticide use by vegetable growers in Bangladesh: a health literacy perspective in relation to non-communicable diseases.

FAO/WHO. 2011. Codex alimentarius commission.

Gesesew, H.A., K. Woldemichael, D. Massa and L. Mwanri. 2016. Farmers Knowledge, Attitudes, Practices and Health Problems Associated with Pesticide Use in Rural Irrigation Villages, Southwest Ethiopia.

Gupta, R., S.J. and Y.P. 2022. Health implications of pesticide residues in food: A comprehensive review. Journal of Environmental Health Research 21:45-57.

Hasan, M., A.Z. Chowdhury, N. Karim, A.N.M. Fakhruddin, S. Hossain, A.K.M.A. Chowdhury, H. Akter and K. Alam. 2014. Contamination and Health Risk Assessment of Pesticide Residues in Vegetables from Agricultural Fields of Gazipur District, Bangladesh. Journal of Agriculture & Environmental Sciences 14:421-427. https://doi.org/10.5829/idosi.aejaes.2014.14.05.12338

Hasan, M., and A. Rahman. 2019. Pesticide residues in selected vegetable collected from wet markets of Bangladesh. Advances in Social Sciences Research Journal vol. 6.

Hussain, S., K.M.A. and A.Z. 2022. Neurotoxic effects of pesticides and the need for regulatory control.

Ismail, M. 2021. What Is Agriculture and Its Importance? Linkedin.

Jallow, M.F., D.G. Awadh, M.S. Albaho, V.Y. Devi and B.M. Thomas. 2017. Pesticide knowledge and safety practices among farm workers in Kuwait: Results of a survey. International Journal of Environmental Research and Public Health vol. 14.

Kesavachandran, C.N., M. Fareed, M.K. Pathak, V. Bihari, N. Mathur and A.K. Srivastava. 2009. Adverse health effects of pesticides in agrarian populations of developing countries. In Reviews of Environmental Contamination and Toxicology 200:33-52.

Kyu Park, B., S. Hee Kwon, M. Sook Yeom, K. Sig Joo and M. Je Heo. 2022. Detection of pesticide residues and risk assessment from the local fruits and vegetables in Incheon, Korea.

Nguyen Dang Giang, C.I., D. Bao Chau Le, V. Hop Nguyen, T. Long Hoang, T. Van Thi Tran, T. Phuong Linh Huynh, T. Quynh Trang Nguyen, K. Ma and B. Dinh. 2022. Assessment of pesticide use and pesticide residues in vegetables from two provinces in Central Vietnam.

Rahman, M.S., M.A. Malek and M.A. Matin. 1995. Trend of pesticide usage in Bangladesh. Science of The Total Environment 159:33-39.

Wakim, S. and M. Grewal. 2021. Organization of the Body.

Shammi, M., A. Sultana, N. Hasan, M. Mostafizur Rahman, M. Saiful Islam, M. Bodrud-Doza and M. Khabir Uddin. (2020). Pesticide exposures towards health and environmental hazard in Bangladesh: A case study on farmers' perception. Journal of the Saudi Society of Agricultural Sciences 19:161-173.

Shariful Islam, Md. 2016. Farm Level Pesticides Use in Patuakhali and Comilla Region of Bangladesh and Associated Health Risk. Journal of Health and Environmental Research 2:20.

Sooman, A. and S. Macintyre. 1995. Health and perceptions of the local environment in socially contrasting neighbourhoods in glasgow. Health & Place 1:15-26.

Seraj., S. 2022. Role-agriculture-bangladeshs-economic-growth. The Daily Star.

WHO. 2022. Pesticide-residues-in-food.

Zabed Hossain, M., F. Ferdous and M.I. Rayhan. 2024. Pesticide knowledge and attitude among the potato growing farmers of Bangladesh and determinant factors.