PESTICIDE RESIDUE IN VEGETABLES FROM COLLECTION CENTERS OF DIFFERENT DISTRICTS IN NEPAL

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ABSTRACT

Pesticide residues in vegetables pose a significant public health concern in Nepal, where systematic residue monitoring remains limited. This study assessed the occurance of pesticide residues in commonly consumable vegetables collected from major collection centres across Nepal and examined their statistical association with selected post-harvest quality parameters. Vegetable samples collected from different collection centers around Nepal were subjected to Rapid Bioassay of Pesticide Residue (RBPR) test kit to examin residue of Carbamate, Organophosphate, Synthetic-Pyrethroid and Dithiocarbamate. 71% of samples were detected with synthetic pyrethroid followed by dithiocarbamate (25%), organophosphate (3%) and none with carbamate. 2% of sample were found at hazardous level of organophosphate, 50% of synthetic-pyrethroid and 2% for dithiocarbamate at unsafe level. The research findings indicate the presence of pesticide residues in common vegetables and recommend validation, comparison and assessment with acknowledging the limitation of preliminary screening RBPR and following other advance test with larger sample sizes.

1. INTRODUCTION

Agriculture continues to be the mainstay of Nepal's national economy, accounting for over 23.95% of the country's Gross Domestic Product (GDP) (NRB, 2021/22) and engagement of around 60.4% of population (AITC, 2022). Together with the production and self-sufficiency of food being a serious issue, protection of agricultural commodities on and off field has also become a problem to be addressed. As Nepal together with several countries in the world has focused more towards conventional agriculture and pesticide as an easy means to kill these pests, Nepal introduced pesticide in 1952 (Aryal et al., 2016). The rural dwelling are the primer drivers if Nepalese agriculture but always placed to the bottom in the need of commercialized agriculture which needs higher use of improved and hybrid cultivars, machinery, fertilizers and pesticides the fear of under recognitions and dream to sustain themselves to commercialization leads to unmanaged utilization of these resources such as pesticides (Nyaupane, 2021).

The wider and incorrect perspective of farmers as their only chemical measures available for quick and easy cure of pests in the field has been accelerating the consumption of these poisons together with improper handling and not applying improper waiting period continuously exposing the farmers and consumers to their health hazards. In the field of agriculture, the utilization of pesticide has become indispensable in the least development countries like Nepal where farmers to compete with the international market need a quick, efficient and cheap method to get rid of the pest (Atreya et al., 2011). According to the Rapid Bioassay Pesticide Residue (RBPR) analytical facility at Kalimati, out of the total 1903 analyzed samples, 5 require quarantine and 22 require disposal in 2016/17 (PPD, 2017). The Central Development Region has the greatest pesticide usage of all the development regions, with 1.015 a.i. Kg/ha. The use is more prevalent in agricultural commodities such as brinjal, tomatoes, root vegetables, green vegetables, and so on whose residue is becoming a growing problem due to a lack of effective testing and monitoring. (Kalauni & Joshi, 2019). Though on an average basis the consumption of pesticide inactive ingredient of Nepal is very low compared to other countries such as India (0.481 Kg/ha), China (2.0-2.5 Kg/ha), Japan (10.8 Kg/ha), Europe (1.9 Kg/ha) and USA (1.5 Kg/ha) (Sharma, 2019), Nepal's annual import of pesticides in FY 2021/22 i.e., 1135504.35 Kg a.i. is 44.9 % higher as compared to FY 2020/21 and 20 folds increase in the last two decades (PQPMC, 2022). Contrary to the idea of learning from other nations Nepal has been acting in opposition to what other nations have been doing to lower their annual pesticide usage, such as Sweden, which has decreased by 68%, Indonesia by 65%, and India, which has decreased during the past year (Atreya et al., 2012).

Poisoning by pesticides is a major concern around the world, but estimates vary. According to Rajendran (2003), chemical pesticides cause over 500,000 diseases and 20,000 deaths worldwide each year. According to WHO data, 3,000,000 cases of pesticide poisoning are reported each year around the world, with 220,000 deaths (Down to Earth, 2001). Human exposure to the Pesticides even at modest concentrations causes chronic health impacts such as immune suppression, hormone disruption, reproductive abnormalities, and damage of kidney, liver, neural region, cancer and malignancies (Mnif et al., 2011). Several cancer cases have been documented in India as a result of pesticide residue in food (Mittal & Vishwakarma, 2014; Rao, 2016). Poor farming practices have been recognized as a major cause of pesticide residue in food and poisoning by cutaneous and oral consumption in impoverished countries.

Different research by Rijal et al. (2018), Sapkota et al. (2020) at different part of Nepal reported that the majority of farmers don't use protective measures in the field and as well do not follow the waiting periods after pesticide application which is the foremost reason for the producer and consumer contamination. The analysis of 50 human blood samples from Ludhiana and Nepal shows that pesticide residues occurred with a frequency of 96 and 94 %, respectively, in which the levels were higher in the Nepalese population (Shrestha et al., 2011). Despite having a low national average in comparison to other nations in the globe, pesticide use for agricultural purposes is rising in Nepal. However, compared to other nations, the danger and hazards to farmers are greater (Ghimire and G.C., 2018).

One of the most pressing needs of the Nepalese economy is and will continue to be sufficient food production and independency of supply. Pest control is heavily reliant on chemicals and pesticides for the majority of commercialized farmers. Despite the fact that many of them are aware that pesticides are harmful to their health, they appear to overlook this knowledge and treat the chemicals as if they are innocuous. As a result of their exposure to harmful pesticides on a regular basis, farmers as well consumers experience both acute and chronic health impacts.

So, in order to decrease the negative effects of chemicals on human health, a thorough study of every meal we consume is critical. However, the program RBPR by Nepal government is still in infancy and is primarily focused on data collected in and around Kathmandu, Nepal's capital and unknown to the scientific communities (Giri et al., 2012). Following the existing literatures in Nepal which has mapped out the baseline pesticide use accompanying with acute and chronic health hazards (Atreya et al., 2012; Bhandari et al., 2019), a critical gap remained on how the field level contamination comprimises the food quality and producer to consumers health. So, research was conducted in the year 2022 to assess the pesticide residue level within vegetables produced from different part of Nepal.

2. MATERIALS AND METHODS

The research is completely based on primary data obtained by pesticide residue assessment of vegetable samples collected from different part of Nepal.

Site selection and sample preparation: All together 126 vegetable samples were collected (3 replication of each) and each replication from different stalls representing different farmers from different collection centres across Nepal which gave a variance residue result within the replication as well. (Figure 1, Table 1) within the month of April to June, 2022.

Table 1. Different locations and different vegetables under research

SN	Locations	Vegetables
1	Jhapa	Bitter gourd, Cowpea, Green Chilli, Okra and Tomato
2	Sarlahi	Bitter Gourd, Brinjal, Cowpea, Cucumber, Green Chilli, Okra, Tomato
3	Kavre	Beans, Bitter Gourd, Cowpea, Cucumber, Green Chilli, Summer squash, Tomato and Sponge Gourd
4	Nuwakot	Beans, Bitter Gourd, Cucumber and Summer squash
5	Bhaktapur	Beans, Brinjal and Summer squash
6	Dhading	Beans, Bitter Gourd, Brinjal, Okra, Cucumber and Sponge Gourd
7	Kailali	Beans, Bitter Gourd, Brinjal, Cucumber, Green Chilli, Okra, Summer squash and Tomato

A rigorous and systematic approach applied for vegetable samples (Bittergroud, Beans, Brinjal, Cowpea, Cucumber, Green chilly, Okar, Summer squash, Sponge gourd and Tomato) each replicated three times from different stalls in compliance with the FAO rules (1999) allowed a diverse range of examination, contributing to a comprehensive and diversed understanding of pesticide residues and nutrient parameters. After collection, the samples were placed into zip lock plastic bags to maintain their integrity and prevent contamination during transportation. Vegetable samples using a knife excluding the tops such as the sepal and peduncle, was prepared according to annex I of European Commission regulation (EC) No. 333/2007 EU (2010) and well mixed. Each sample's leftovers were stored in a separate plastic bag at -10 ^{0}C until pesticide residue analysis was completed.

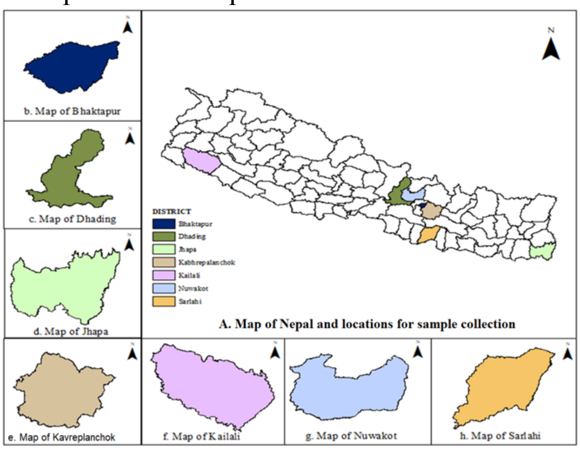

Figure 1. Map of Nepal and sample collection sites

Assessment of pesticide residue: Rapid Bioassay of Pesticide Residue (RBPR) lab, Kalimati Kathmandu Nepal with RBPR test kit method and PY/DTC kits under Standerd Operating Procedure (SOP number: RBPR/01/2017) developed by Plant Protection Directoriate were applied to analyze Carbamate, Organophosphat (OP) pesticidal resiude. During analysis of Carbamate and Organophosphate, the reduction of absorbance for the sample to control (Blank) test was compared and the inhibition %age of the enzyme was calculated and grouped as follows.

$$Enzyme\ inhibition(\%) = \frac{\{Absorbance\ change\ (Control) - Absorbance\ change\ (Sample)\}}{Absorbance\ change\ (Control)} \times 100$$

The inhibition % than were categorized as per the following rule;

Table 2. Indicator for carbamate and organophosphate residue

Inhibition	Indicator	Description
Below 35%	1	Not harmful consumption as pesticide residue was found low
35%-45%	2	Need to keep in quarantine for minimum 2 days as the presence of pesticide residue was found in considerable amounts that may be degraded withholding for a certain period.
Above 45%	3	Not suggested for sale and consumption purposes since a significantly high amount of pesticide residue was found in the sample.

(Source: Ghimire, 2020)

For synthetic pyrethroid (PY) and Dithiocarbamate (DTC) kits developed by Taiwan Agriculture Research Institute (TARI) have been used to assess the insecticide and fungicide residue in each vegetable sample. These kits include a series of chemicals which is used in different concentrations to result in the final color in the mixture and is analyzed on the basis of a color chart.

Statistical analysis

The data obtained after lab analysis of collected samples werefirst gathered and managed using MS Excel: Descriptive analysis. Data analysis was performed using R-studio 4.3.1: Kruskal-Wallis test and SPSS base 23.0

Limitations of the study

The study has the limitation as RBPR only operates as prilimary screening mechanism limiting the delivery the direct quantitative parts-per-million(ppm), nor isolating the individual chemical isomer. Howevery these basic indices are valuable to have a regional survelliance to pesticide residue further requiring sophisticated assessment [Gas Chromatography-Tandem Mass Spectrometry (GC-MS/MS) and Liquid Chromatography-Mass Spectrometry (LC-MS/MS)] and evaluation.

3. RESULTS AND DISCUSSION

Pesticide residue in vegetables

The research synthetic pyrethroid were the group of pesticide detected in highest portion of vegetable samples i.e. 71 % followed by dithiocarbamate 25 %, organophosphate 3% and none of the samples were detected with the carbamate pesticide residue during research period (Figure 2). Survey Report on National Pesticide Consumption Statistics in Nepal (2014) and PPD (2015) identified that the highest portion of pesticides in Nepal had been consumed by vegetable commodities followed by cash crops and Cereals. Additionally, according to CBS (2006), the proportion of vegetable growers using pesticides increased from 7.1% in 1991/92 to 16.1% in 2001/2002. The reason for Synthetic Pyrethroid pesticide showing residue in highest number of samples was because of its chemical nature considered to be amongst the safest insecticides (Yadav & Devi, 2017). Bhandari et al. (2019) found 97% of vegetables were detected with at least one pesticide residue (organophosphates, organochlorines, acaricides, fungicides, and insecticides of biological origin) among crops from Southern Nepal i.e. Eggplant, Chilli and Tomato.

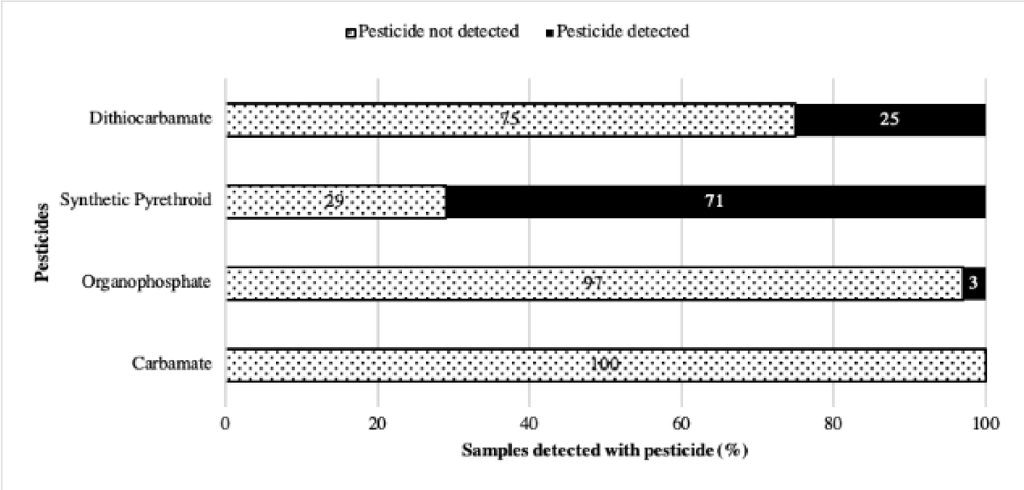

Figure 2. Pesticide residue with in vegetable samples under analysis

Organophosphate pesticide residue in vegetables

The research results that among the samples analyzed all together 2 % of samples were at hazard level of organophosphate pesticide where sponge gourd and tomato were only two vegetables detected with residue. 11% of sponge gourd vegetable were detected with quarantine level of organophosphate pesticide residue and 25 % of tomato vegetable were detected with hazard level of organophosphate pesticide (Figure 3). The result was also supported by Ghimire (2020) where tomato and cowpea were the major vegetable with high residue of organophosphate pesticide collected from commercial pocket of Nepal i.e. Sarlahi and Kavre district. Koirala et al. (2009) also found that the organophosphate pesticide residue under their research was at highest level on root vegetables followed by leaf vegetables. Koirala et al. (2010) in their research to identify pesticide residue in vegetable samples from five different districts of Nepal observed organophosphate to be one of the major identified pesticides to be applied in the field by farmers. Koirala et al. (2010) in their research to identify pesticide residue in vegetables from different districts of Nepal found majority of residue belongs to the moderately hazardous group of pesticides as per WHO classification and the organophosphate group of pesticides belongs to this group. The absence of residues aligns with the susceptibility to rapid environmental hydrolysis and higher water solubility (Yadav & Devi, 2017)

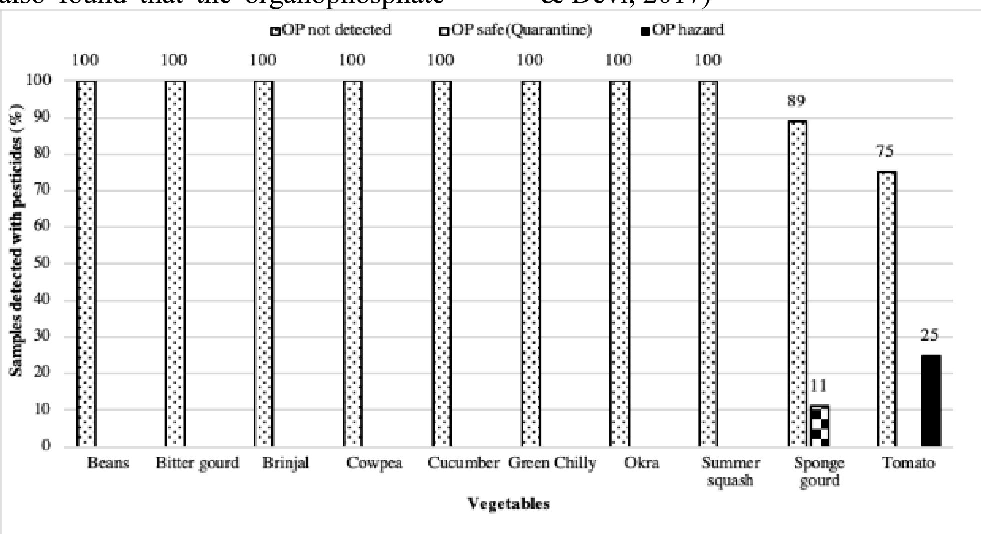

Figure 3. Vegetable-wise organophosphate residue

Synthetic pyrethroid pesticide residue in Vegetables

The result shows that among different vegetable samples analyzed for synthetic pyrethroid pesticide residue 50% of vegetables were detected with hazard level where sponge gourd samples was the vegetable with highest portion residue followed by cowpea (89%), beans (86%), summer squash (84%), tomato (75%), brinjal (67%), green chilli (66%), okra (67%), cucumber (60%) and bitter gourd (45%) was the vegetable with lowest portion of samples detected (Figure 4). Research by Koirala et.al. (2010) in five different districts of Nepal identified that cypermethrin was a common pesticide applied by farmers in the field which belong to the synthetic pyrethroid group. Another research by Sharma (2015) also found the highest residue of cypermethrin and Deltamethrin from the synthetic pyrethroid group of pesticides in tomato and brinjal from the central region of Nepal. As per GC and Palikhe (2021-22) a wider perception to farmers that only chemical applications are available to control pest effect in their crop and lack of awareness, management of chemical and governmental regulation leads to over utilization and residue of pesticides in our vegetables reaching to consumers with a sever health impact on the applicator as well. The result was also supported by research done by Bhandari et.al. (2019) with vegetable farmers of Dhading which reported that farmers use maximum pesticides, mostly in tomato and only 56% follow the waiting period. High frequency of synthetic pyrethroid aligns with regional pesticide use trend (Bhandari et al., 2019) and lipophilic nature favoring long-term binding with cuticular waxy layers (Yadav & Devi, 2017).

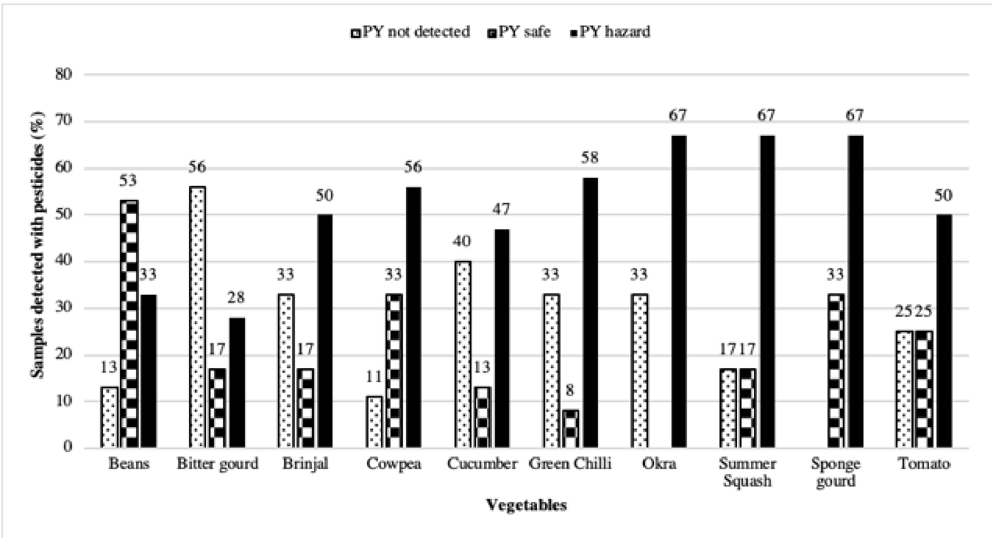

Figure 4. Vegetable-wise synthetic pyrethroid pesticide residue

Dithiocarbamate pesticide residue in vegetables

The result shows that among different vegetable samples analyzed for dithiocarbamate pesticide only 2%(3 Samples) of samples showed the unsafe level of pesticide residue where brinjal(50%) was the vegetable with highest portion of samples detected with pesticide followed by green chilli (33 %), summer squash (33 %), sponge gourd (33 %), tomato (33 %), bitter gourd (28 %), cucumber (20 %), cowpea (11 %), okra (8 %) and beans (7 %) was the vegetable with lowest portion of samples detected (Figure 5). Research by Sharma (2015) in the central region of Nepal under pesticide residue analysis of vegetables identified the residue of carbendazim and mancozeb to be highest in tomatoes followed by bottle gourd and chilli. The mancozeb belongs to the dithiocarbamate group of pesticides.

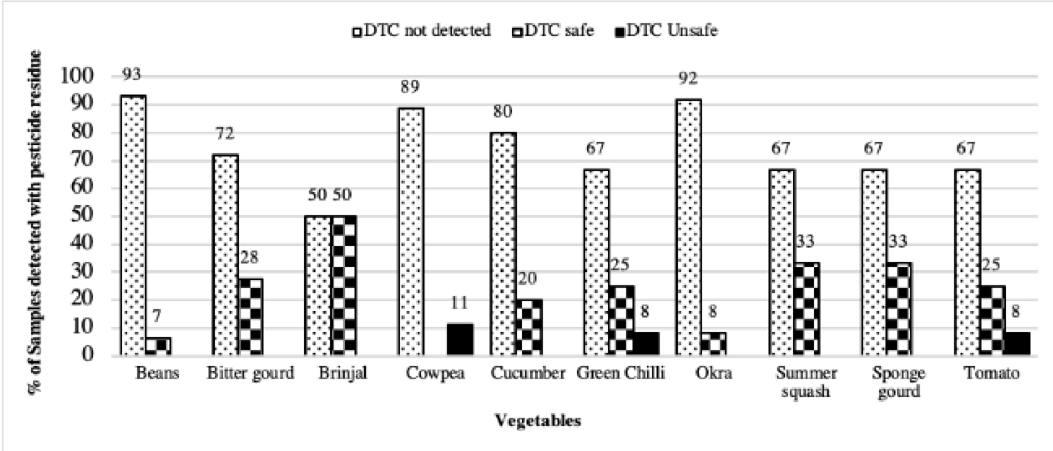

Figure 5. Vegetable-wise dithiocarbamate pesticide residue

4. CONCLUSION

In conclusion, this investigation highlights significant presence of pesticides in majority of the vegetables within distribution channel. Most of the samples exhibiting the presence of pesticide underscores a need of immediate systematic and continuous residue assessment facilities across regional collection centers safeguarding public health and ensuring food safety. Furthermore, the research suggests requiring comprehensive and sophisticated test procedure advanced than RBPR to result evidences. The investigations emphasize that implementing local RBPR points will provide practical on farm data's and help to screen national food system supporting agriculture supply chain.

The research findings should be further validated and experimented within upcoming days with more samples from different parts of Nepal as well agriculture imports specifying pesticide. A comparative analysis with the application of different pest management practices in the farmer's field in comparison to biological solutions together with washing methodology before the consumption of vegetable is needed after this research as most of the samples were identified with contact pesticide.

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