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EXPOSURE ASSESSMENT OF THE KENYAN POPULATION TO PESTICIDE RESIDUES THROUGH VEGETABLE CONSUMPTION

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ABSTRACT

The output of a pesticide residue surveillance program (detection frequency and number of exceeding measures) can lead to unnecessary concern among consumers since they lack information concerning the actual exposure. In this study, the exposure to pesticide residues through vegetable consumption is evaluated based on the 2011-2016 national pesticide residue surveillance data of the Kenya Plant Health Inspectorate Service (KEPHIS). The results indicated that maximum consumers of kales exposure to residue was between 2 to 71 times higher than the corresponding acceptable daily intake (ADI) for the pesticides studied for the total population while for tomatoes consumption only chlorpyrifos exposure was more than 2 times higher than ADI. However, it was demonstrated that cooking reduced the exposure by the average of 90%. For the probabilistic exposure assessment, results indicated that the exposure of the consumers and general population (adults) was generally under control even at high or frequent consumption of vegetables. For most of the pesticide residues studied, the exposure is one hundred times lower than the acute reference dose (ARfD) and ADI. In the risk assessment, the results showed that occurrence of pesticide residue in vegetables could not be considered a serious public health problem. Nevertheless, an investigation into continuous monitoring and tighten regulation of pesticide residues in vegetable in whole country is recommended. The risk assessment study, including the proposed mitigation measures, can be a valuable input for risk managers such as food safety authorities.

INTRODUCTION

Different pesticides are applied to control insects and diseases on crops to increase production.

Pesticide residues on vegetables constitute a possible risk to consumers.

The human health concerns range from short-term impacts such as headaches and nausea to chronic impacts like cancer, neurotoxicity, reproductive harm, and endocrine disruption (Berrada et al., 2010). Food is the main exposure route-Five orders of magnitude than air and drinking water (Juraske et al., 2009). Vegetables are mainly consumed raw or semi-processed-higher pesticide residue levels. Given the potential risk of pesticides for public health, the use of pesticides in agriculture is subjected to constant monitoring. In Kenya, some of the most prevalent pesticides detected during monitoring programs include, Chlorpyrifos, Lambda Cyhalothrin, Alpha-cypermethrin, Azoxystrobin, Dimethoate , Profenofos , Carbendazim and Diazinon.

The output of a pesticide residue surveillance program (detection frequency and number of exceeding measures) can lead to unnecessary concern among consumers since they lack information concerning the actual exposure.

OBJECTIVE OF THIS STUDY

Perform exposure assessment of Kenyan Population to Pesticide Residues through consumption of Vegetables.

MATERIALS AND METHODS

1. Pesticide Residue Data

- 2011-2016 NPRMP from KEPHIS.
- Samples: Tomatoes (n=319) and Kales (n=584).
- 90 pesticides analysed.
- Pesticides detected more than 5 times per commodity selected.

Highly consumed commodities were chosen (Tomatoes and Kales) derived from KIHBS 2004-2005 by KNBS. 13,158 Households surveyed in the whole country. The research was based on seven day food consumption. Average number of people per household was five. Individual weights not taken- used 60kgs basis used (JMPR, 2016).

2. Consumption Data

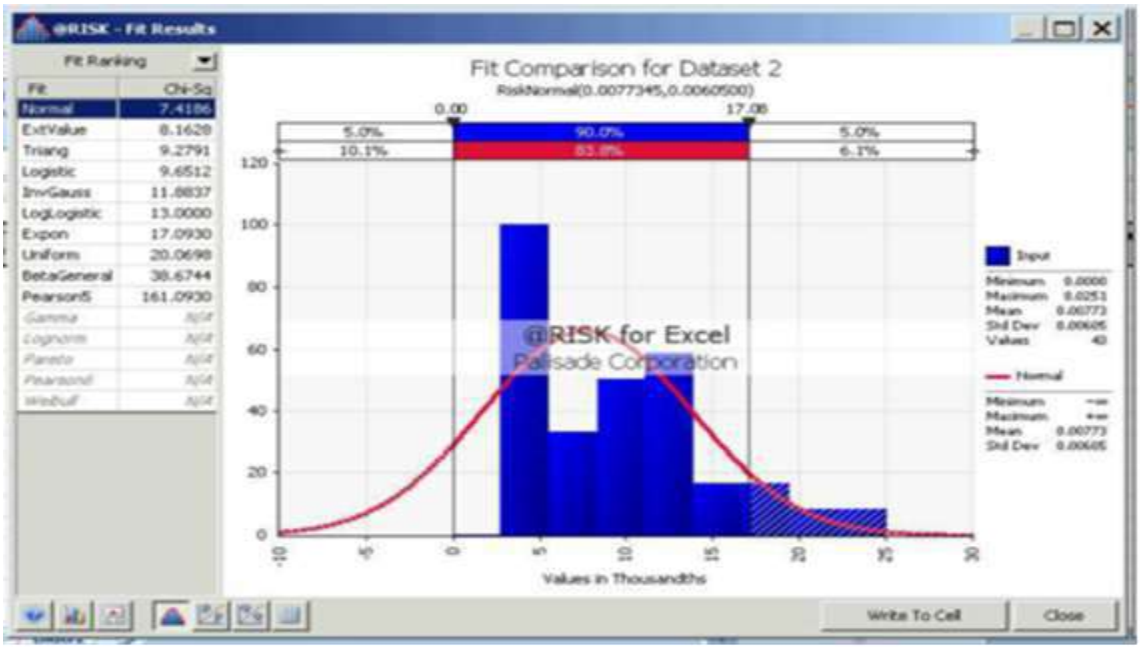
3. Exposure Assessment

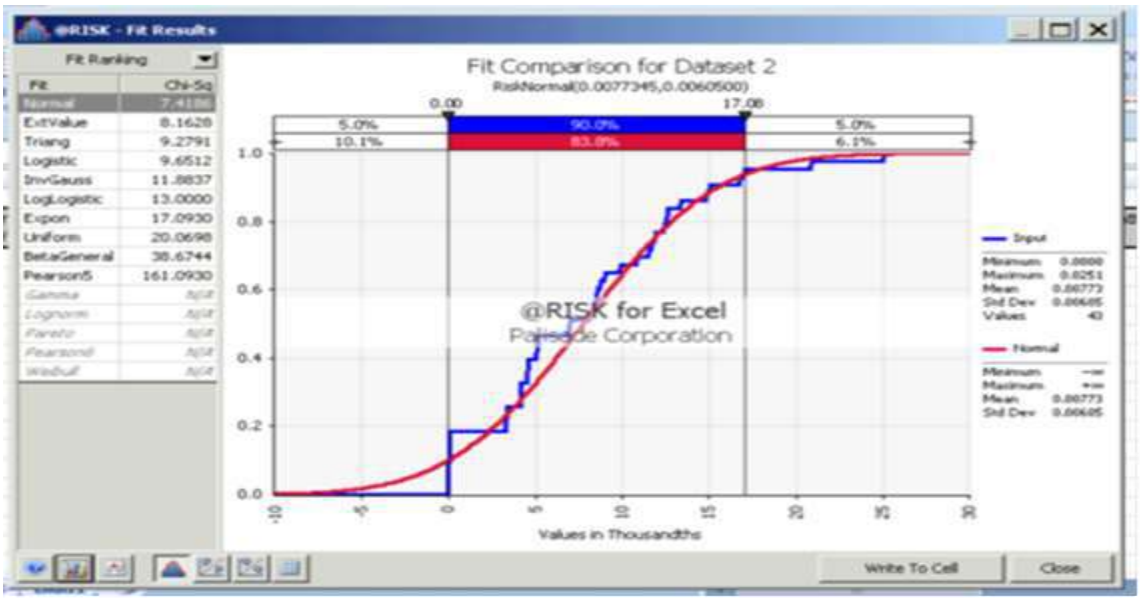
Contamination of Food Products (mg/kg)	X	Consumption of Food Products (kg/kg) BW/day	=EXPOSURE (mg/kg BW/day)
Database 1		Database 2	

Deterministic Approach-Estimated intakes were calculated by multiplication of the mean, maximum and P 97.5 percentile of the contamination levels with the corresponding mean, maximum and P 97.5 percentile of the consumption data of each vegetable category.

ESTI=C xRxv EDI=C x R

Probabilistic Approach-Probability distributions fitting for the consumption and contamination data of each food category was performed in using the Risk software.

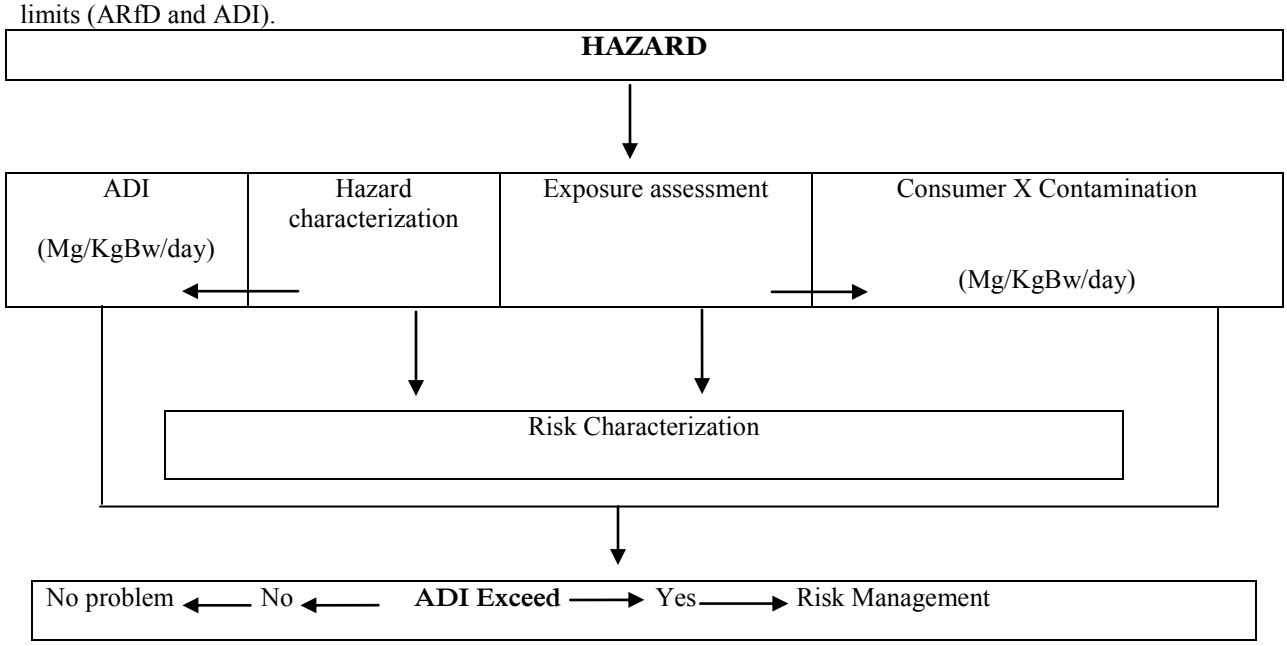




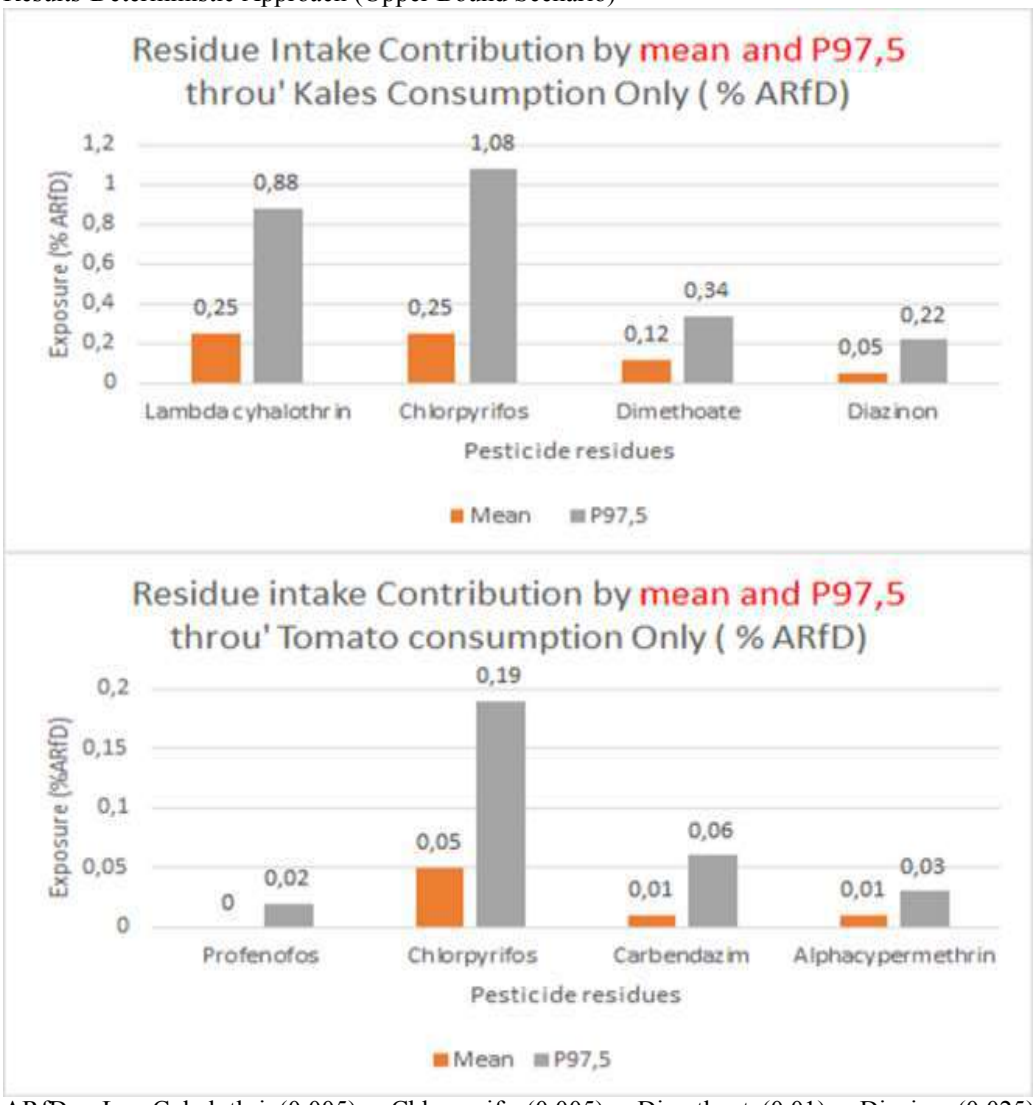
Two scenarios were evaluated; Lower bound (non detects=0) and Upper bound (non detects=LOD) Upper bound scenario (Worst case scenario of the two) reported in the study.

The vegetables were assumed to be eaten raw

4. Risk Characterization- Exposure assessment estimated intakes of residues were compared to toxicological limits (ARfD and ADI).



Results-Deterministic Approach (Upper Bound Scenario)



ARfD; L. Cyhalothrin(0.005), Chlorpyrifos(0.005), Dimethoate(0.01), Diazinon(0.025), Profenofos (1), Carbendazim (0.02) and Alphacypermethrin(0.04). The higher consumers (P97.5) are exposed to high residue intakes than the average consumers. No risk for both P97.5 and average consumers (all residues < 100% of the ARfD).

1. Residue Intakes by Maximum Consumers of Kales and Tomatoes

Pesticide	Commodity	*ARfD	*ADI	Estimated daily intakes by Kenyan population according to upper bound scenario expressed as ratios of ARfD and ADI	
				Consumers only	Total Population
				Max	Max
Lambda Cyhalothrin	Kales	0.005	0.0025	**1.8919**	**4.8139**
Chlorpyrifos	Kales	0.005	0.001	0.3954	2.0547
Dimethoate	Kales	0.01	0.001	**4.2697**	**71.0345**
Diazinon	Kales	0.025	0.0002	0.0917	11.7413
Profenofos	Tomatoes	1	0.03	0.0102	0.1031
Chlorpyrifos	Tomatoes	0.005	0.001	0.329	2.1263
Carbendazim	Tomatoes	0.02	0.02	0.0769	0.0896
Alpha Cypermethrin	Tomatoes	0.04	0.015	0.0048	0.0129

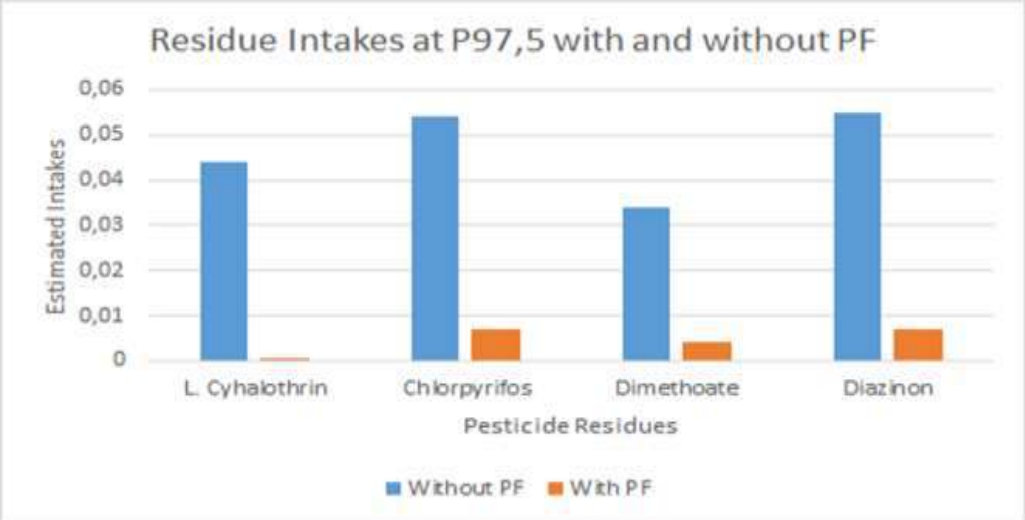
The Maximum consumers had highest estimated residue intakes. Acute risk for L. Cyhalothrin and Dimethoate for kales and Chronic risk for L. cyhalothrin, chlorpyrifos, dimethoate, diazinon for kales and chlorpyrifos for tomatoes.

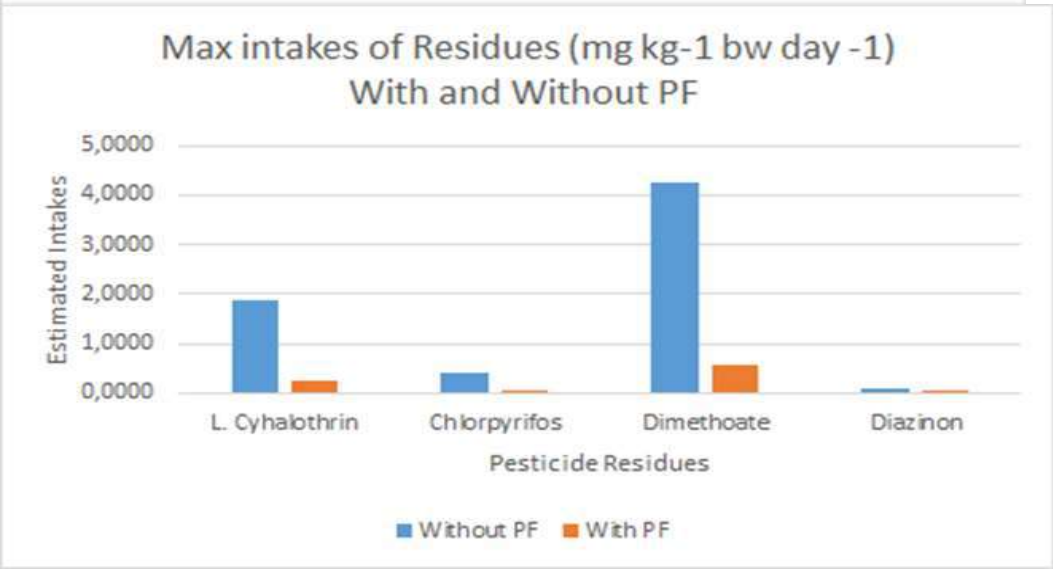
2. Results-Probabilistic Approach

Pesticide	Commodity	Estimated residue intakes for the Kenyan population according to upper bound scenario ($\mu g\ kg^{-1}\ bw\ day^{-1}$)									
		Consumers only					Total Population				
		Mean	P50	P97.5	P99.5	Max	Mean	P50	P97.5	P99.5	Max
Lambda Cyhalothrin	Kales	0.015	0.008	0.071	0.121	0.353	0.008	0	0.056	0.114	0.225
Chlorpyrifos	Kales	0.009	0.004	0.078	0.162	0.272	0.005	0	0.053	0.131	0.222
Dimethoate	Kales	0.002	0.008	0.094	0.213	0.484	0.009	0	0.065	0.215	0.425
Diazinon	Kales	0.007	0.032	0.081	0.161	0.251	0.002	0	0.052	0.113	0.463
Chlorpyrifos	Tomatoes	0.003	0.002	0.015	0.025	0.046	0.002	0	0.012	0.022	0.312

Consumers and total population high intake at Max and higher percentiles. No risk illustrated by this approach. Probabilistic Mean and P97.5 estimated intake lower than in the Deterministic estimates indicating overestimation of deterministic exposure analysis.

Effect of Processing Factors on residue estimated intakes at Max and P97.5 for Kales Consumers.





Processing factors (PF) were considered for deterministic exposure analysis. PF of 0.13 for cooking used (Juraske et al). Decrease of 98%, 87%, 88% and 87% for L. Cyhalothrin, Chlorpyrifos, dimethoate and diozinon at P97.5 and 87%, 78%, 87% and 87% at Max consumption. Same results for Total population were observed.

CONCLUSION AND RECOMMENDATION

Deterministic Approach results indicated risk unlike Probabilistic Approach results due to overestimation. Cooking reduced pesticide residue concentration by an average of 90%. No public health concern on Kenyan population due to pesticide residues in vegetables.

The recommendation was Processing (Cooking) be done before consumption of vegetables. Due to many uncertainties of the study, it is recommended that a detailed investigation be carried out-new consumption data.(especially on infants & children) and larger scope of pesticide residues Surveillance and monitoring programs be carried out to verify GAP compliance/contamination levels for future exposure assessments

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