Published by
NIGERIAN SOCIETY OF PHYSICAL SCIENCES
Available online @ https://asr.nsps.org.ng/index.php/asr

African Scientific Reports 5 (2026) 576

African Scientific Reports

Pesticides kinematic properties nexus to aqueous environments for elimination from foodstuffs before food

E. K. Ukpoko[a,*], I. S. Eneji[a], Q. M. Amua[b], R. A. Wuana[c], S. M. Tongu[a], W. U. Ukpoko[d]

[a]*Chemistry Department, College of Physical Sciences, Joseph Sarwuaan Tarka University, Makurdi, Nigeria*
[b]*Chemistry Department University of Agriculture, Science and Technology, Ihugh, P.M.B 102060 Makurdi, Benue State, Nigeria*
[c]*Environmental Sustainability Department, Joseph Sarwuan Tarka University, P.M.B 2373 Makurdi, Nigeria*
[d]*Chemistry Department, Rev. Fr. Moses Orshio Adasu University (Benue State University) P.M.B 102119 Makurdi, Nigeria*

Abstract

The practice of applying pesticides on grains of foodstuffs in greater quantities for storage has become a norm without eliminating them before selling to consumers. This research has determined the environmental nexus to kinematic properties with the potency to eliminate such pesticides in foodstuffs before preparation for consumption. Foodstuff samples of white beans, red guinea corn, and white maize were considered. Three of the most patronised pesticides; aluminium phosphide, dichlorvos with chlorpyrifos, and permethrin in Benue Markets, were considered and analysed for kinematic properties. The results showed that solubility, density and thermal volatility are kinematic properties of pesticide nexus for elimination from grain foodstuff in aqueous solvent environments upon analysis before and after treatments using UV-visible spectrophotometer. The solubility state of dichlorvos with chlorpyrifos in aqueous solvents indicates that both are insoluble with low density to float on the aqueous environment and easily eliminated by decantation. Also, by thermal fusion through hot aqueous before mixing with foodstuff, it enhances instant volatility kinematic effect of dichlorvos with chlorpyrifos to evaporate into the air, leaving the grain foodstuff free in aqueous. Furthermore washings of foodstuff in hot aqueous dilute and eliminate dichlorvos with chlorpyrifos out of foodstuff. Permethrin and aluminium phosphide are sparingly insoluble in aqueous environments, whereas parts of these float while parts settle under foodstuff in aqueous environments due to density. The first elimination was decantation followed by flood sieving of grain foodstuff with aqueous solvents severally, eliminates these micro pesticides to a bearable minimum as shown in results.

DOI: 10.46481/asr.2026.5.3.576

Keywords: Pesticides, Elimination, Foodstuffs, Kinematic properties, Aqueous-treatment

Article history:
Received: 18 June 2026
Received in revised form: 25 September 2026
Accepted for publication: 03 October 2026
Available online: 05 November 2026

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1. Introduction

Chemical pesticides are of great advantage in boosting foodstuff production and conservation but also a great challenge to food insecurity in terms of unsafe chemicals [1, 2]. These pesticides are mostly observed in grains and foodstuffs that are produced in greater quantities because they do retain great nutritional values during a long-term storage period.

*Corresponding Author Tel. No.: +234-703-768-1809.
Email address: ukachiiemma@gmail.com (E. K. Ukpoko)

In Benue State, the predominant grain foodstuffs are millets, beans, rice, maize, guinea corn, etc. They are the most available, affordable, and important foodstuffs [3]. Due to many production challenges, the conservation by storage of these foodstuffs with pesticides has become common in our society to boost foodstuff availability [4] even out of season, making the grain foodstuffs unsafe from harmful chemicals, which is the main concern in this study.

Pesticides will therefore continue to play roles for boosting foodstuff production and conservation to storage in agriculture food chain. However, the risk factors from exposure to pesticides to humans and the environment is a daily concern [4–8]. Among all the factors of food insecurity in terms of pesticides in/on foodstuff safety is neglected by most people, and as such poisons are ingested with food daily.

According to Amua and Ukpoko [9], the pesticides application surveyed result review that, three active chemicals of Aluminium phosphide, dichlorvos with chlorpyrifos, and permethrin in different brands names emerged the top demanded or patronized pesticides of insecticides for grains foodstuff storage at 37.5 %, 33.3 %, 20.8 % respectively and the rest insecticides shared in 8.33 % only. On a separate note, a similar survey report by Pii *et al.* [4] reviewed that patronized pesticides were aluminium phosphate tablets which ranked 80% for storage pesticides, while dichlorvos was 60% and DDT was 35% [9]. (Note: chlorpyrifos was officially banned in Nigeria on 1st Nov., 2024 by NAFDAC, under the leadership of Prof. Mojisola Christianah Adeyeye, FAS Director- General) though it was found in the brand name of dichlorvos pesticide used here according to Ukpoko *et al.* [2], and as such it was treated as a composite pesticide of dichlorvos with chlorpyrifos in this research, for intrinsic scientific reality.

Many publications have reviewed sophisticated methods in which pesticides have been extracted from foods like; meat, meat products, dairy food products, fish and seafood, and eggs etc, follow with the cleaned up processes, and isolated by chromatographic techniques for in laboratory identification and quantification analysis [10–14] but not or less of elimination methods to free the foodstuff for consumption.

This research is design to determine the environmental nexus on some pesticides kinematics for simple aqueous solvent systemic elimination from grain foodstuff before preparation for consumption.

2. Materials and methods

2.1. Collection of grain foodstuff sample

Three foodstuff samples of white beans, red guinea corn, and white maize, which were free from pesticides, were purchased, 3 kg directly from farmers in the field for spike samples, blank, pesticide and solvent sorption studies. Also, 1 kg of white beans, red guinea corn, and white maize each was purchased from three (3) wholesalers (WS), same beans, red guinea corn, and white maize from three (3) retail sales (RS), then it was merged respectively to make 3 kg in each case from five markets. A total of ninety (90 WS, RS) samples were collected to make fifteen (15) composite sample from wholesalers (WS) and fifteen (15) from retailers (RS) in five markets, for assessment of pesticide before and after its elimination treatment.

2.2. Collection of pesticides sample

This research team used the information according to Amua and Ukpoko [9], which reviewed that, three active chemicals of; aluminium phosphide, dichlorvos with chlorpyrifos, and permethrin in different brands emerged as the top demanded or patronised insecticides for grain foodstuff storage at 37.5%, 33.3%, and 20.8%, respectively, and the rest of the insecticides were shared in 8.33% only to make a choice of pesticide for this study. Hence, the commonly used pesticides for storage of foodstuffs in Makurdi Town are aluminium phosphide, dichlorvos with chlorpyrifos and permethrin. Dichlorvos (2,2-dichlorovinyl dimethyl, DDVP) made by Gongoni Co. Ltd, it contained chlorpyrifos according to Amua and Ukpoko [9], Aluminum phosphide: 56 % m/m Min., inert ingredients: 44 % m/m max. 20 tablets x 3 = 60 g. Reg. No.-5-4(11), manufactured and exported by SUMITOMO CHEMICAL INDIA LTD. Permethrin a pyrethroids: 0.60 %, inert carriers 99.40 %, average net 100 g, NAFDAC Reg. No. A5-0240 product batch: 0819-A1/In/11-17/APV-SAHEL. Made by Gongoni Co. Ltd . These commonly used insecticides were purchased and analysed for some aqueous environmental conditions with nexus effects on the kinematic properties of these pesticides, respectively.

2.3. Kinematic properties of pesticides in aqueous environments

The kinematic properties of pesticides were analysed to determine the relationship with the grain foodstuffs, materials and the choice of solvents and environments that could be suitable as means for the elimination of pesticides. The kinematic properties analysis includes density, pH, aqueous solubility, foodstuff sorption, and thermal volatility.

2.3.1. Determination of density

In the case of solid or powder samples, a 15 mL measuring cylinder was weighed and gently filled with the pesticide powdered sample just above 10 mL. By gently tapping the bottom of the cylinder on the laboratory bench till there was no further diminution of sample level, the sample volume and weight were measured and recorded. Then bulk density (BD) was calculated using the equation.

The expression is given in Eq. (1):

$$\text{BD} = \frac{\text{Weight of substance (g)}}{\text{Volume of substance (cm}^3\text{)}}. \tag{1}$$

In the case of a liquid sample, a 15 mL measuring cylinder was weighed and gently filled with the liquid pesticide sample using a dropper pipette to the 10 mL mark. Then the sample volume and weight was measured and recorded [15]. Then the specific density (SD) was calculated as;

The expression is given in Eq. (2):

$$\text{SD} = \frac{\text{Weight of substance (g)}}{\text{Volume of substance (cm}^3\text{)}}. \tag{2}$$

The expression is given in Eq. (3):

$$\text{RD} = \frac{\text{Weight of substance (g)}}{\text{Weight of equal volume of water (g)}} \times 100\%. \tag{3}$$

2.3.2. Determination of pesticide solubility

Solubility is the ability of a substance known as a solute to form a solution with another substance called a solvent. Insolubility is the opposite property, the inability of the solute to form such a solution.

A. Solid pesticide solubility.

A filter paper on the clean rectangle glass with the solvent of quest for solubility was flooded, allowed to dry for 5 minutes, then it was dried in the oven at 105 °C for 30 minutes (this is to remove any soluble and volatile contents from the filter paper, if present and to ensure constant weigh). The dried filter paper was removed, weight and recorded. The filter paper was folded into a small funnel with a short extension, then exactly 1 gram of the compound, whose solubility is to be determined was weighed, into the funnel or a clean, dry filter crucible of known weight.

Then the sample was soaked and flooded using aspirator with known volume of solvent from 10 mL to the volume at which the solute dissolved completely or failed to dissolve further (when saturation is observed, the used solvent remove and replace until equilibrium is reached within 1000 mL) with the solvent, then it was allowed to stay in the solvent for 1 hour. Then the filter paper was removed, dried at a stable temperature of the substance in an oven for two hours, and reweighed; the residual value of solute left was used to calculate solubility extent.

In the case of thermal solubility, sample was soaked in a beaker with the given amount of solvent, and was placed on a thermostatic water bath. The temperature and time was set. The loss of weight of the solute left in the given volume of solvent is given as: Weight before soaked (W1) minus weight after soaked and flooded (W2) = weight loss (W3) = solubility (Heather *et al.* [16], modify by determination of residual solute left to calculate the extent of solubility).

The expression is given in Eq. (4):

$$w_1 - w_2 = w_3. \tag{4}$$

The expression is given in Eq. (5):

$$\%\ \text{Solubility} = \frac{W_1 - W_2}{W_1} \times 100. \tag{5}$$

B. Liquid pesticide solubility.

A measuring cylinder of 100 mL was filled with the solvent of solubility quest to the 9 mL mark. Then 1 mL of solute for the solubility study was added to complete the 10 mL volume. Whether the solute dissolves completely or fails to dissolve further, cover with a stopper or cork. The contents were shaken vigorously for 5 minutes and was allowed to settle, and observed. The homogeneity or decreases in the measure of solute volume at the partition layer indicate the level of solubility of the solute.

In another way, the remaining volume of solute measured from the partition layer equals the insolubility limit of the liquid solute. Where saturation seems to play a role, a syringe is used to removed the saturated solvent and replaced it. In a thermal solubility study, the cylinder with the content will be shaken and placed in a thermostatic water bath at a set temperature and time. The solubility of the V/V equation is given as: solubility = initial volume of solute (1 mL) minus the end volume of solute [16]), modify the determination of residual solute left to calculate the extent of solubility).

The expression is given in Eq. (6):

$$\text{Solubility (V/V)} = V_1 - V_2. \tag{6}$$

Table 1: Descriptive terms for solubility extent from the percentage of solute remaining.

Sn	Remark terms	% range of solute left
1	Very soluble	<1
2	Freely soluble	1 to 10
3	Soluble	10 to 30
4	Sparingly soluble	30 to 100
5	Slightly soluble	100 to 1000
6	Very slightly soluble	1000 to 10,000
7	Practically insoluble or insoluble due variables	≥ 10,000

The expression is given in Eq. (7):

$$\% \text{ Solubility} = \frac{V_1 - V_2}{V_1} \times 100. \tag{7}$$

This method can be used to study solubility with many variable factors.

C. Calculation of descriptive extent of molar solubility.

The extent of solubility is widely ranging from infinite in some solutions, that is, totally soluble or miscible. Examples include ethanol in water and titanium dioxide in water. Hence, seven descriptive terms are used to qualify the extent of solubility for a given factor(s) in solubility studies [17].

The thresholds for describing something as insoluble" or similar terms may depend on the application. For example, one source states that, substances are described as "insoluble" when their solubility is less than 0.1 g per 100 mL of solvent.

In this research, we modified the solubility method of Heather *et al.* [16] and developed a yardstick equation to calculate the percentage extent of solubility, which is to be described in seven terms from the result of the calculation using the equation.

The expression is given in Eq. (8):

$$\% \text{ Solubility extent} = \frac{\text{Weight or volume of solute left}}{\text{Initial weight or volume of solute}} \times 100\%. \tag{8}$$

The numeric result was compared to the ranges in Table 1 of the descriptive terms for solubility extent from percentage solute left and initial to ascertain the extent solubility of that pesticide.

2.3.3. Determination of foodstuff pesticide sorption

The pesticide-free foodstuffs that were selected for study were Sun dried for 6 hours and tagged, respectively. A 10 g or 10 cm3 Pesticide of study was measured and dropped in the bottom of sterilized desiccators in contact with 1 g weighed grains of foodstuff for direct contact. Also the dried, known weighed grains of foodstuff was placed on a mesh and fixed above the pesticide in the desiccators for indirect contact, covered, and allowed to stay for one week. The foodstuff sample was reweighed, and the changes in weights were recorded for pesticide sorption by grains and sorption rate was calculated using the formula [15]:

The expression is given in Eq. (9):

$$\text{Pesticide sorption} = W_2 - W_1 = W_3. \tag{9}$$

The expression is given in Eq. (10):

$$\% \text{ Pesticide sorption rate} = \frac{\text{Change in weight of grains } (W_3)}{\text{Time taken}} \times 100\%. \tag{10}$$

2.3.4. Determination of foodstuff attrition (att.)

The foodstuff was dried at 100 °C for 5 minutes and weighed (W1). The known mass of the foodstuff grain sample was added into 5 mL. solvent in a 10 mL test tube and stoppered with a cork; then it was shaken vigorously for the stipulated time of 5 min. The foodstuff samples were removed and dried at the same 100°C for 10 minutes again and reweighed (W2). The weight (W3) lost after contact with the solvent was calculated as the attrition value of the food samples per contact time [15].

The expression is given in Eq. (11):

$$(W_1) - (W_2) = W_3. \tag{11}$$

The expression is given in Eq. (12):

$$\% \text{ Attrition} = \frac{W_1 - W_2}{\text{Initial sample weight } (W_1)} \times 100. \tag{12}$$

2.3.5. Thermal volatility and residues

A clean, oven-dried 50 mL beaker was weighed empty and recorded. Then 1 g of the equivalent of the pesticide was weighed in the beaker and recorded. In a thermostatic water bath, the beaker with pesticide was heated at 25°C for one and two hours, respectively. The reduction in weight from the 1 g at a particular temperature is equal to the thermal volatility and residue rate of the pesticide at that temperature, which were calculated using the formula [15]:

The expression is given in Eq. (13):

$$\text{Thermal volatility rate} = \frac{\text{Change in weight of 1 g pesticide}}{\text{Time taken (1 h at } T)}. \tag{13}$$

The expression is given in Eq. (14):

$$\% \text{ Thermal volatility rate} = \frac{\text{Change in weight of 1 g pesticide}}{\text{Time taken (1 h at } T)} \times 100. \tag{14}$$

The expression is given in Eq. (15):

$$\% \text{ Residues} = 100 - \% \text{ thermal volatility value}. \tag{15}$$

2.4. Determination of pesticide before and after elimination in foodstuff

2.4.1. Pesticides elimination by kinematic properties nexus to hot aqueous environments

Samples of grain foodstuffs with pesticide were treated as follows: Each sample of foodstuff was measured up to 200 g into an open plastic bowl, respectively. Distilled and deionised water was boiled in a kettle to 100°C, and 400 mL was poured into 200 g sample into an open plastic bowl. The foodstuffs in open plastic bowls were gently stirred at 100 rpm and allowed to stay for 2 minutes during which the heat in water mobilized and diffused the volatile pesticide kinetically out of grain foodstuff into water for possible dilution and evaporation in air.

Kinetically some pesticide diffused out of foodstuff, activated by heat in water and moved, due to density and insolubility stability, floated on the top layer of the aqueous solution like oils, foam, dust and etc, and was eliminated by decantation (This simple elimination should not be carried out in a closed pot or kettle to avoid foodstuff re-absorption of the condense pesticides under pressure as the grains may turns softer in the process). Then the whole sample was overturned on the basket and washed by flooding with at least 1 L of clean water (distilled and deionised) while gentle shaken to wash out the high dense particles of pesticide that may settle with the foodstuff in sieve. Repeat the elimination process until the wash out water is within pH 5- 5.55 for white beans, 5–5.30 for White Maize and 5–5.20 for guinea corn. This is to ensure elimination of the pesticide to a bearable minimum,

2.4.2. Aqueous extraction of pesticides for determination

Exactly 100 g of respective foodstuff samples were weighed into 200 mL beakers with warmed water of 45 °C and were allowed to stay for six hours, with occasional gently stirring at 150 rpm of the solution. Considering the density of each pesticide in aqueous solution as shown Table 4, each sample was taken from positions in which the pesticide's concentration is expected in aqueous solvents base on it relative density and solubility. The solution was filtered through silk wool and the extracted filtrate was allowed to settle under 25 °C. The extract was stopped in amber bottles and kept at the temperature below 25 °C to be used for spectroscopy determination of aluminium phosphide, dichlorvos, chlorpyrifos and permethrin.

2.4.3. Spectroscopic determination of phosphide insecticides for aluminium phosphide

In a 200 mL beaker, a fine powder of ammonium molybdate 4-hydrate (2.97 g) was dissolved in 100 mL of distilled deionised water and shaken vigorously. Ammonium meta-vanadate (0.15 g) also dissolved in a 200 mL beaker with 100 mL of distilled deionised water, was shaken vigorously. Then the two solutions were mixed to produce a faint purple colour. This formed vanadate-molybdate in a solution of weak acid of pH 6.5 to 6.9. This vanadate-molybdate reagent is a mixture of ammonium molybdate [$(NH_4)_6Mo_7O_{24}$] and ammonium metavanadate [NH_4VO_3] in HCl [18].

Procedure: Homogeneous 4 mL aqueous extracts from sample filtrate and blank obtained in test tubes, 0.5 mL of the combined ammonium vanadate-molybdate reagent was added and mixed by shaking and inversion. The reagent was added to all prepared solutions (including serial dilutions for standard calibration), and they were allowed to stand at least 10 minutes for the colour to develop fully before taking absorbance readings. The absorbance of each standard, sample, and blank was measured at 214 nm. The values of the standard were calculated; a calibration graph of absorbance against phosphide concentration (in mg) of the standard solutions was plotted in Figure 1. This graph was used to determine the phosphate (as P) concentration of aluminum phosphide in each extract sample, considering dilutions of the sample in our calculations, after the sample blank reading was subtracted by instrument tare from the corresponding samples in each case . The results of optical intensity absorbance of the solutions were displayed converted and reported per mg/L concentration [19], as shown in Table 4.

The expression is given in Eq. (16):

$$C = A/\varepsilon \times \iota, \tag{16}$$

where C = Concentration of the absorbing substance (units of mol/L or molarity).
A = Absorbance (no units, as it is a logarithmic ratio of light intensities).
ε (epsilon) = Molar absorptivity (or molar extinction coefficient), which shows how strongly a chemical species absorbs light at a specific wavelength (units of $L.Mol^{-1}.cm^{-1}$).
(ι) = Path length of the cuvette or distance the light travels through the solution (usually measured in cm.

2.4.4. Spectroscopic determination of organochloride dichlorvos

The 4.0 mL of the analyte sample and the standards containing dichlorvos of serial dilutions for calibration and the blank were taken in a 10 mL graduated tubes, and in each 1.0 mL, 1 M sodium hydroxide is mixed. The solutions were kept for 15 min at room temperature for complete hydrolysis. Then 1 mL of p-aminobenzoic acid is added to each, shaken thoroughly, and the pH is adjusted between 9.2 and 9.4, respectively. The solutions were kept for 25 minutes for full colour development and then diluted to the mark with water in case the colour developed tense above Beer's Law, where 1 mL of 1.0 M is sufficient for the complete hydrolysis of sodium hydroxide. Exactly 1 mL of p-aminobenzoic acid was sufficient for complete colour development. An excess amount of reagent decreases the intensity of colour. Absorbance was measured at 415 nm, respectively, against the blank reagents using a UV-Visible Spectrophotometer [20]. A calibration graph of absorbance against concentration (in mg) of the standard solutions was plotted and was used to quantify dichlorvos with Eq. (16).

2.4.5. Spectroscopic determination of permethrin

The extract of 4.0 mL of the permethrin was filtered through silk-wool and quantitatively transferred into a 10 mL screw-covered test tube and allowed to settle alongside a serial dilution of permethrin for calibration. The extract was pipetted into a cuvette, and absorbance was measured against a blank at 290 nm [21] in each case. The results of optical intensity absorbencies of the solutions were displayed and reported in absorbance. Standard concentrations (mg) of permethrin were plotted and were used to determine it in samples using Eq. (16), through which the amount of permethrin was calculated and presented in Table 5.

2.4.6. Spectroscopic determination of chlorpyrifos

Exactly 2.5 mL of the extract was transferred. through filtration into a 10 mL along with serial dilution for calibration of Chlorpyrifos, in tube, then 5 mL of of sodium hydroxide was added and heated for 3 minutes at 30-45°C under optimum tight conditions for complete hydrolysis, and it was allowed to cool. Then 0.5 mL of diazotised 2-amino-8-hydroxyquinoline was added. It was shaken thoroughly and kept at 0-5°C for 10 minutes for full colour development in the freezer. The colour reaction involves the coupling of diazotized 2-amino-8-hydroxy quinoline with 1, 2, 4-trichloropyridine (TCP) that forms orange-yellow dye, and absorbance was measured at 416 nm [20]. Values for standard serial dilution of chlorpyrifos were used to plot a calibration graph of absorbance against concentration (in mg) through which Concentrations of pesticides assessed in foodstuffs were calculated. The results of optical intensity absorbance of the solutions were converted using Eq. (16) and reported in mg/L concentration, as shown in Table 5.

3. Results and discussion

Generally, the physicochemical properties of substances or compounds are helpful in identifying the position of analyst concentration in samples or in sample matrix, even in the extraction solutions. Such properties could also help to adapt precautionary measures

Table 2: Physicochemical properties of foodstuffs in aqueous solvent.

Sn.	Parameters	Aqueous
1	Density g/cm^3	0.99 ± 0.02
2	pH at 30°C	7.00 ± 0.00
	White Beans	5.55 ± 0.05
	White Maize corn	5.25 ± 0.05
	Red Guinea corn	5.16 ± 0.04
3	Attrition (%) at 89–42°C (5 min); mg/g	
	Beans	+1.63 ± 0.08
	Maize Corn	+1.02 ± 0.08
	Red Guinea corn	+0.86 ± 0.04

Note: + indicates percentage weight gained from the solvent; - indicates percentage weight lost to the solvent.

to secure analytes in samples during handling [22]. Hence, pesticides have been among delicate compounds, and the knowledge about the basic kinematic properties of such specific, commonly identified pesticides used in a community is a nexus to help their simple systemic elimination in/on foodstuffs by consumers.

The attrition and sorption properties of grain foodstuffs in aqueous solvents during extraction of target pesticides from foodstuffs or matrices were determined and are presented in Table 2.

The percentage sorption of pesticides by grain foodstuff investigated and the presentation of physicochemical properties of foodstuffs in contact with the insecticides, especially the sorption of insecticides on direct and indirect contact, is presented in Table 3. Also aqueous environment factors related to kinematic properties of pesticides, especially insecticides, was determined, and these include density, pH, thermal volatility, and solubility of the insecticides in solvents for possible elimination in foodstuff is presented in Table 4. which shows kinematic properties with systemic separation of pesticides from foodstuff and possible systemic elimination.

Thirty composite foodstuffs samples of white bean, red guinea, corn and white maize were collected in triplicate as wholesale (WS) and retail sales (RS) from each of five markets: High Level, North Bank, Wadata and Wurukum and assessed for pesticides before and after pesticide elimination treatment. The results are presented in Table 5.

The data for the three foodstuffs are presented in Table 5 and its continued parts (Tables 5 and 5).

3.1. Ph of foodstuff in aqueous

The density of the aqueous solvent used in the research was 0.99 ± 0.02, and the pH of same aqueous was 7.00 ± 0.00 which are all within the scientific range of purity for analytical purpose. Acidic ions are more soluble in alkaline solutions and vice versa. The pH of white beans, red guinea corn, and white maize in the same solvents ranges from 5.55 ± 0.05, 5.25 ± 0.05, and 5.16 ± 0.04 in Table 2, and as such, all are in the weak acidic range. This is a clear indication that the pH of the foodstuffs in the extraction aqueous solvent environment is within the median of the weak acidic range; hence, it could not just release natural ions from the foodstuff content into the solvent during pesticide elimination treatment except the pesticide with extreme acidic ions.

3.2. Attrition of foodstuffs in aqueous

The attrition property of foodstuffs in hot aqueous solvent boiled at 100 °C, then 100 mL was and added into 50 g of grain foodstuff, the temperature drop down to 89 °C suddenly when mixed with foodstuff . Then it preceded dropping to 42 °C within the ambient temperature of 32 °C in five minutes. Negative attrition recorded in five (5) minutes, indicating that the three foodstuffs of white beans gained +1.63 ± 0.08 % mg/g, red guinea corn +1.02 ± 0.08 % mg/g, and white maize +1.02 ± 0.08 % mg/g rather than attrition of natural content into the aqueous solvents, which ensure original nutritional content retention. The negative attrition will also dilute the pesticides that may be absorbed in the grain foodstuff to a tolerable level as bio-detoxification. This suggested the suitability of water not just as a universal solvent but as a solvent with environmental nexus on the kinematic properties of pesticides elimination treatment in/on foodstuffs.

3.3. Kinematics properties of pesticides sorption in/on grain foodstuffs

Kinematic sorption properties of pesticides by foodstuffs, on direct and indirect contact are presented in Table 3, and have shown significant results as follows: white beans adsorbed and absorbed on direct contact a maximum of 46.17±0.07 % mg/g dichlorvos with the chlorpyrifos brand, 1.33±0.07% mg/g permethrin, and 1.36±0.09 % mg/g aluminium phosphide of grains, respectively.

White maize on average absorbed 17.3-18.2 ± 0.03% mg/g dichlorvos with chlorpyrifos, 3.08-4.68 ± 0.07% mg/g permethrin and 0.960-1.18 ± 0.01% mg/g aluminium phosphide of grains on direct contact.

Red guinea corn absorbed an average percentage of 6.80 - 19.1 ± 0.01% mg/g chlorpyrifos in the dichlorvos and then adsorbed 0.23 - 1.62 ± 0.06 % mg/g permethrin and 0.240 - 0.520 ± 0.07 % mg/g aluminium phosphide of grains on direct contact. Quantitatively

Table 3: Kinematic properties of pesticide sorption in/on grain foodstuffs.

Parameters per grain	Dichlorvos (chlorpyrifos)	Permethrin	AlP
pH at 30°C	6.08 ± 0.01	5.36 ± 0.02	6.66 ± 0.02
Sorption test at 29–32°C in 24 h			
Direct-contact sorption (% mg/g)			
White Beans	18.1 - 46.2 ± 0.07	1.27 - 1.33 ± 0.07	1.16 -1.36 ± 0.09
White Maize corn	17.3-18.2 ± 0.03	3.08 - 4.68 ± 0.07	0.960 - 1.18 ± 0.01
Red Guinea corn	6.80 - 19.1 ± 0.01	0.23-1.62 ± 0.06	0.240 - 0.520 ± 0.07
Non-contact sorption (%)			
Beans	11.09- 11.8 ± 0.06	0.290 - 2.32 ± 0.04	0.920-1.26 ± 0.08
Non-contact sorption (% mg/g)			
Red Guinea corn	6.45 - 7.31 ± 0.07	0.580 - 0.620 ± 0.02	0.290- 0.63 ± 0.05
WHO MRL for grains foodstuff (mg/kg)	0.01-2 (0.01-0.05)	0.05- 2.0	0.01- 0.1

AlP = aluminium phosphide; MRL = maximum residue limit.

Table 4: Pesticide kinematic properties relevant to elimination from grain foodstuffs.

Parameters per 1g equivalent	Dichlorvos	Permethrin	AlP
Density (g/cm^3)	0.801 ± 0.002	1.41 ± 0.0	0.738 ± 0.001
E. Conductivity(μS/cm at 30°C)	137.000 ± 1.1	87.1 ± 6.9	68.4 ± 0.4
pH at 30°C	1.40 ± 0.0	5.57 ± 0.1	5.87 ± 0.1
Solubility at 30°C			
Aqueous	White ppt insoluble	Slightly soluble	Slightly soluble
n-Hexane	Soluble	Soluble	Very slightly soluble
Carbon-tetrachloride	Soluble	Sparingly soluble	Very slightly soluble
Volatile matter at 25–32°C (% mg/g)			
1 hour	89.8 ± 0.3	0.0100 ± 0.1	1.46 ± 0.2
2 hours	97.7 ± 0.4	0.0900 ± 0.1	1.48 ± 0.3
3 hours	97.7 ± 0.2	0.100 ± 0.2	1.51 ± 0.4
Residual matter at 25–32°C (% mg/g)			
1 hour	10.2 ± 0.3	99.9 ± 0.1	98.5 ± 0.2
2 hours	2.29 ± 0.4	99.9 ± 0.2	98.5 ± 0.2
3 hours	2.27 ± 0.2	99.9 ± 0.2	98.4 ± 0.4

AlP = aluminium phosphide; ppt = precipitate.

it showed that these foodstuffs have absorbed pesticides on direct and indirect contact reasonably to an unacceptable limit stipulated by WHO [23] maximum residual limit.

Non-contact absorption pesticides of insecticide by white beans, white maize, and red guinea corn is greatly significant, with dichlorvos with chlorpyrifos > permethrin > aluminium phosphide in the maximum range of 14.8±0.04 to 0.62±0.02, % mg/g o grains as presented in Table 3. This sorption experiment showed that grain foodstuff could absorb 6-18 % mg/g of pesticides depending on variable factors of permeability.

The significant percentage weight gained without obvious optical changes in grains from adsorption and absorption of these pesticides is of great health risk to consumers at short- and long-term human health indices, according to WHO [23]. This is one among the major kinematic properties of pesticides relativity to grain foodstuffs that required the development of pesticide elimination treatment of foodstuffs prior to food preparations. The results of the sorption physicochemical properties of foodstuffs with the pesticides of insecticides by direct and indirect contact have shown that most grain foodstuffs retain reasonable percentage amount of insecticide applied to them, especially when applied directly to the foodstuffs hence, simple removal treatment techniques are required to reduce it to a tolerable level.

3.4. Pesticide kinematic properties in aqueous environments

3.4.1. Volatile pesticides percentage (%)

At a temperature of 25-32°C, dichlorvos with chlorpyrifos brands are very volatile to lose 97.73 ± 0.2% mg/g, maximum from foodstuff into hot aqueous solvent environment, leaving just 2.27 ± 0.2 mg/g residues, whereas at elevated aqueous temperatures, it is capable of withdrawing all the dichlorvos with chlorpyrifos portioned in foodstuffs into water to evaporate, making it a huge success

for its removal in/on grain foodstuffs to minimal value as shown in Table 4. This is a clear indication that more than 97.73 ± 0.2 % mg/g of dichlorvos with chlorpyrifos can evaporate on hot water boiled at 100°C to a bearable minima in solution. It also proves why dichlorvos and chlorpyrifos dealings are critical in temperate regions.

3.4.2. Pesticides densities

The density of dichlorvos with the chlorpyrifos brand and aluminium phosphide insecticides are 0.8011±0.0002 and 0.7383±0.0001 g/cm2 less than that of 1 g/cm^3 density of water, hence the relative density activate the pesticide to eluted into solution by heat from water to kinematically migrate to float at the top layer in an aqueous solvent environment; hence, the top layer of aqueous solution is the target for decantation elimination of dichlorvos with chlorpyrifos and some aluminium phosphide in aqueous solution. This property can be used to at least reduce the amount of these pesticides in grain foodstuffs by mixing and washing with hot water, then decant the pesticide on the top layer of water. Water been the abundant universal solvent in food preparation; its relative density with pesticides has paved a way for cheap and tremendous removal of dichlorvos with with chlorpyrifos and permethrin in raw grain foodstuffs before cooking. Hence, differences in density between the foodstuffs and the pesticides or insecticides in aqueous solvents have recorded a breakthrough for the removal of some insecticides in foodstuffs to a bearable minimum.

The permethrin with the density of 1.4087±0.0 is expected to be concentrated at the lowest layer of aqueous extract; hence, the lower layer of aqueous extract is the target section for its elimination in aqueous environments. These parameters enable the picking of the target elimination at the right point of its high concentration. The density of the whole permethrin can be reduced from food samples by also washing with warm water and allowing it to settle down before collecting the foodstuff by upward sieving or overturned the foodstuff on the basket or sieve to eliminate it by extensive downward flooding. The removal techniques based on differences in density of insecticides and foodstuffs in aqueous solvents, also the volatility temperatures of the insecticides have proved to be good kinematic property for simple systemic removal techniques for some insecticides from foodstuffs before cooking.

3.4.3. Pesticides solubility and insolubility

In the elimination of pesticides in aqueous solutions, a popular phenomenon for predicting solubility is known as "like dissolves like". This statement indicates that a solute will dissolve best in a solvent that has similar chemical properties to itself, based on the favourable entropy of mixing. This property depends on many variables factors, such as the physical forms and state of the solute and solvent substances, the manner and intensity of mixing, etc. The solubility state of substances in different solvents is the important factor used here for the elimination of pesticide compounds from foodstuffs. For the extraction of the pesticides from foodstuffs, the state of the aqueous solvent is altered, and the property of water, which helps to improve its efficiency for the extraction of natural and synthetic products is attained.

That is when water is heated, its permittivity, viscosity, and surface tension decrease significantly, while its diffusion properties increase as the temperature increases, as reported by Herrero *et al.* and Bianca *et al.* [24, 25]. When hot water diffused into grains, it helps dilute pesticide to gain kinetic energy to dissolve state and moved out of foodstuff into solution for elimination. Hence, at elevated temperatures and pressures, water displays physicochemical properties of a polar and non-polar solvent [24, 25] accommodating the solubility of both organic and inorganic pesticides to be soluble and eliminated from the foodstuffs using solubility properties.

This view is so simple, and it is a useful rule to consider for the elimination of pesticides in foodstuffs; hence, the overall solvent capacity depends primarily on its polarity. That is, a polar (hydrophilic) solute such as aluminium phosphide is very soluble in highly polar hot water, very slightly soluble in fairly cold water, and practically insoluble in non-polar solvents. In contrast, a non-polar or lipophilic solute such as dichlorvos with chlorpyrifos hydrolysed to form white precipitate, soluble in hot water and slightly insoluble in cold water. The dynamic solubility changes by pesticide eluted from foodstuff when water was hot to evaporate and some agglomerated to floats, precipitated and settle from gently stirring in solution as its cools down has envisage ease of pesticides elimination. As such, floating pesticide content are decanted out of solution. Further elimination of pesticides like permethrin, slightly soluble, some precipitated and settle partly were pull down by down flooding of the sample overturned on a baskets or sieve to wash out all pesticides to a bearable minima.

3.5. Calibration curves for determination of insecticides

From the respective stock solution of insecticides, exactly 1.0 g equivalent quantity of pesticides was prepared in 100 mL of the respective solvents for 10 mg/mL concentrations each. Serial dilutions for five different concentrations in mg/L were prepared considering the Beer-Lambert laws of spectroscopy and color intensity, respectively. The respective sets of serial dilutions were measured on UV-visible spectroscopy at respective wavelengths (λ) to produce calibration curves for each pesticide as the results shows in Figure 1, similar to the report by Vindhiya [20].

Aluminium phosphide spectroscopy methods of determination has a limit of detection (LOD) from 0.005 to 0.1 mg/kg. or (0.1 mg/L).

Dichlorvos limits of detection (LOD) using spectrophotometric or colorimeter (Sodium Hydroxide Hydrolysis) follows Beer's law for concentration ranges from 0.4 to 4 mg on (μg/25 mL scale), with a molar a absorptive of 4.53×10^4 L mol^{-1} cm^{-1} on UV-Vis Spectrophotometry achieved LOD of 0.05- 0.17 μg /L in foodstuff samples [26]. Chlorpyrifos spectroscopy (Molybdate blue) method has a limits of detection (LOD) from 0.026 mg/g - 0.03 mg/L depending on whether it is applied on grains or in aqueous extract

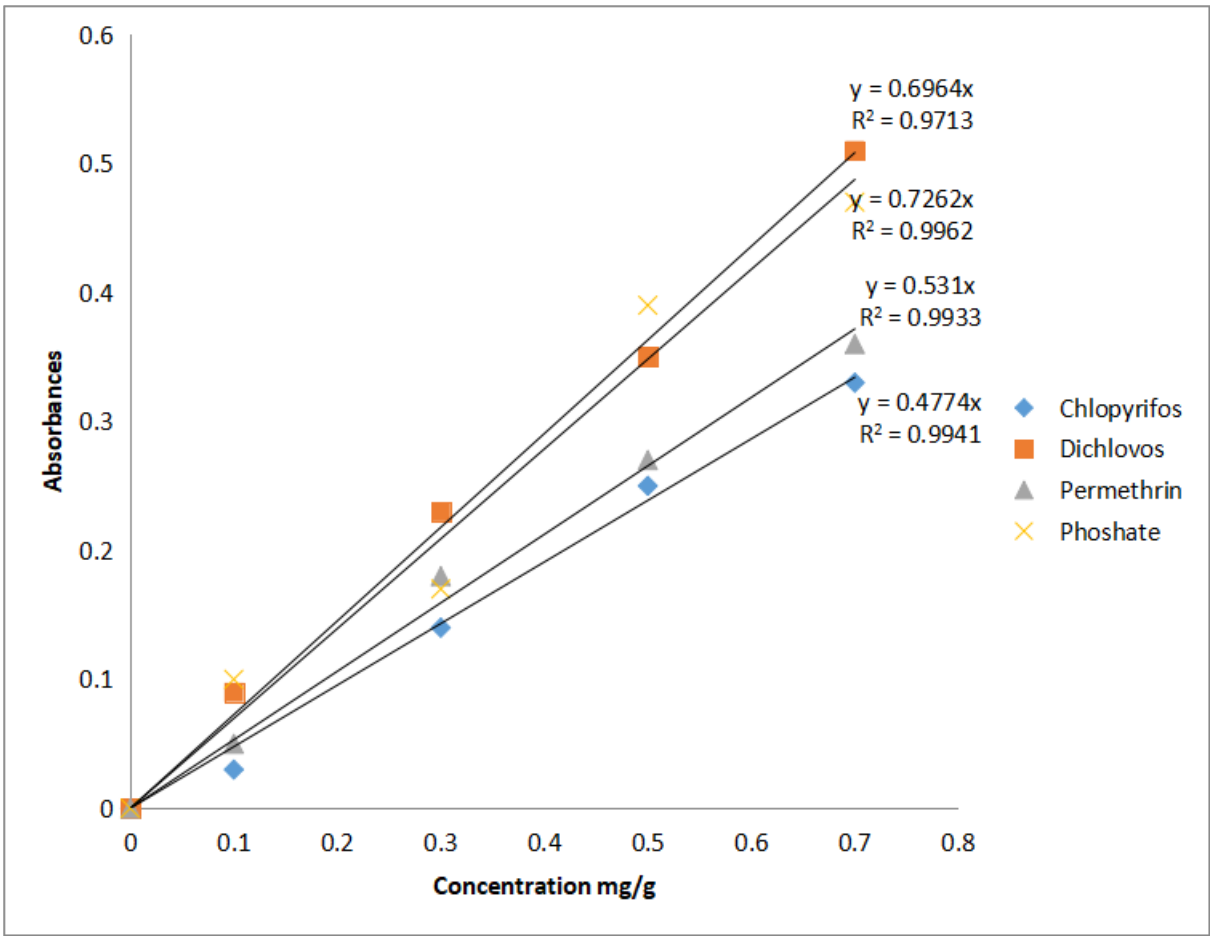


Figure 1: Calibration curves for determination of insecticides.

solutions [27]. Also note that chlorpyrifos was identify in the dichlorvos brand of pesticide used here according to Ukpoko *et al.* [2], hence the mean values determine in each case were merged and reported as one composite pesticide as represented in Table 5 and discussions.

The limit of detection (LOD) for permethrin using spectroscopy methods generally ranges from 0.0035 g/ml -3.5 mg/mL or 4.8 μg/mL, depending on the specific spectroscopic technique and reagent used [20, 26, 27]

3.5.1. Level of pesticides in foodstuff before and after elimination

Pesticides were assessed, before and after pesticide elimination treatment in foodstuffs of white bean, red guinea, corn and white maize samples collected from five markets: High Level, North Bank, Modern Market, Wadata and Wurukum Markets respectively.

3.5.2. Insecticides assessed in white bean foodstuffs

The assessment of pesticides in foodstuffs was done with a UV-visible spectrophotometer, as done by Vindhiya *et al.* [20], to determine the level of pesticide before and after treatment for elimination.

Part of the white bean sample collected from wholesale and retail sellers of grain foodstuffs in five markets was assessed before elimination treatments for identification of the presence of three insecticides of high patronage used for conservation storage of grains food storage in Makurdi.

Before sample treatment for pesticide elimination in foodstuff, aluminium phosphide was detected in both store wholesale (WS) and retail samples (RS) from High Level Market, Modern Market, North Bank Market, Wadata Market and Wurukum Market, in different concentrations, respectively, as presented in Table 5, whereas after treatment using principles of pesticide kinematic properties nexus to aqueous environments, it was below detection by the same instruments, except in the sample from the high-level market, though the concentration reduced from 0.2182±0.002 to 0.0071±0.002, below the validated detection limit, with removal estimates handled appropriately for censored data. This showed that the method is effective for the removal of aluminium phosphide pesticides in grain foodstuff prior to proper food preparation to a bearable minimum, likewise the report of An-An Zhang *et al.* [28] in the case of pesticide removal in fruits and vegetables.

Table 5: Pesticides assessed in white beans before and after elimination using UV-spectrophotometer (mg/L).

Foodstuff sources	Aluminium phosphide (mg/L)		Dichlorvos & Chlorpyrifos (mg/L)		Permethrin (mg/L)	
White beans	Before	After	Before	After	Before	After
Highlevel Mkt (WS)	0.2182±0.002	0.0071±0.002	0.0111±0.001	BLOD	BLOD	BLOD
Highlevel Mkt (RS)	0.1101±0.003	BLOD	BLOD	BLOD	BLOD	BLOD
Modern Mkt (WS)	0.2157±0.002	BLOD	BLOD	BLOD	BLOD	BLOD
Modern Mkt (RS)	0.1097±0.001	BLOD	BLOD	BLOD	BLOD	BLOD
Northbank Mkt (WS)	BLOD	BLOD	0.2571±0.001	0.0100±0.001	0.2121±0.000	BLOD
Northbank Mkt (RS)	BLOD	BLOD	0.1384±0.001	BLOD	0.1165±0.002	BLOD
Wadata Mkt (WS)	0.1105±0.003	BLOD	0.3531±0.001	0.0121±0.001	0.2159±0.001	BLOD
Wadata Mkt (RS)	0.0100±0.002	BLOD	0.0681±0.002	BLOD	0.0061±0.003	BLOD
Wurukum Mkt (WS)	0.2158±0.002	BLOD	BLOD	BLOD	BLOD	BLOD
Wurukum Mkt (RS)	0.1099±0.001	BLOD	BLOD	BLOD	BLOD	BLOD
WHO MRL for grains foodstuff (mg/kg)	0.01–2 (0.01–0.05)		0.05–2.0		0.01–0.1	
Method limit of detection	0.005 to 0.1 mg/kg		0.05–0.17 μg/L and 0.026–0.03 mg/L		0.0035–3.5 mg/mL or 4.8 μg/mL	

Note: WHO = world health organizaton; WS = wholesale samples; RS = retail sales samples; MRL = maximum recommended limit; BLOD = below limit of detection; LOD = limit of detection (also note that chlorpyrifos was identify in the dichlorvos brand of pesticide used here according to *Ukpoko et al [2]* hence the two values were merged after determination and the mean values presented as a composite pesticide).

Before the samples were treated, analyses of the insecticides dichlorvos with chlorpyrifos and permethrin were detected in different concentrations in bean samples collected from the store wholesale (WS)and retail sales (RS) samples in two markets, North Bank and Wadata Markets. This is a clear indication that, these pesticides are present in foodstuffs selling in markets. More than one pesticide is used in preserving grain foodstuff in these markets, especially Wadata Market. The three insecticides of aluminium phosphide, dichlorvos with chlorpyrifos, and permethrin are used competitively for the storage of white beans as shown in Table 5.

After sample treatment using principles of pesticide kinematic properties nexus to aqueous solvent environment, pesticides were only detected in a few samples, such as dichlorvos in beans from wholesalers in North Bank and Wadata, though the concentration reduced after treatment from 0.2571±0.001 to 0.0100±0.001 and 0.3531±0.001 to 0.0121±0.001, respectively as seen Table 5. These residues were below the validated detection limit, with removal estimates within the censored data, similarly as demonstrated in the report by Soniya, *et al.* and An-An Zhang *et al.* [28, 29] in the case of pesticide elimination in fruits and vegetables.

3.5.3. Insecticides assessed in red guinea corn foodstuffs

The samples of red Guinea corn collected from five markets were assessed for the presence of three insecticides before elimination treatment, and aluminium phosphide was detected in both wholesale (WS) store samples and retail sales (RS) samples from High Level Market, Modern Market, and Wurukum Market in different concentrations, respectively.

The insecticide dichlorvos with chlorpyrifos was detected in wholesale store sample at High Level Market, the entire red guinea corn sample from North Bank Market and Wadata Markets, respectively, as presented in Table 5, whereas permethrin was not detected in any red guinea corn sampled from five markets.

After treatment of samples using principles of pesticide kinematic properties nexus to aqueous environment, pesticides of insecticides were not detected in most of the samples again except aluminium phosphide, which was detected in a wholesale sample from Modern Market, though it was reduced from censored data of 0.3164±0.001 to 0.0100±0.001 mg concentration and the residue was below the validated detection limit. Dichlorvos with chlorpyrifos in a wholesale sample from Wadata Market was reduced from 0.4239±0.001 to 0.0010±0.001 mg, as presented in Table 5. The results show that pesticides can be reduced in grain foodstuffs up to

Table 5: Pesticides assessed in white beans before and after elimination using UV-spectrophotometer (mg/L) (continued).

Foodstuff sources	Aluminium phosphide (mg/L)		Dichlorvos & Chlorpyrifos (mg/L)		Permethrin (mg/L)	
White beans	Before	After	Before	After	Before	After
Highlevel Mkt (WS)	0.2162±0.002	BLOD	0.1161±0.002	BLOD	BLOD	BLOD
Highlevel Mkt (RS)	0.0102±0.003	BLOD	BLOD	BLOD	BLOD	BLOD
Modern Mkt (WS)	0.3164±0.001	0.0100±0.001	BLOD	BLOD	BLOD	BLOD
Modern Mkt (RS)	0,0111±0.003	BLOD	BLOD	BLOD	BLOD	BLOD
Northbank Mkt (WS)	BLOD	BLOD	0.2280±0.001	BLOD	BLOD	BLOD
Northbank Mkt (RS)	BLOD	BLOD	0.1183±0.001	BLOD	BLOD	BLOD
Wadata Mkt (WS)	BLOD	BLOD	0.4239±0.001	0.0010±0.001	BLOD	BLOD
Wadata Mkt (RS)	BLOD	BLOD	0.1235±0.002	BLOD	BLOD	BLOD
Wurukum Mkt (WS)	0.2171±0.001	BLOD	BLOD	BLOD	BLOD	BLOD
Wurukum Mkt (RS)	0.1165±0.001	BLOD	BLOD	BLOD	BLOD	BLOD
WHO MRL for grains foodstuff (mg/kg)	0.01–2 (0.01–0.05)		0.05–2.0		0.01–0.1	
Method limit of detection	0.005 to 0.1 mg/kg		0.05–0.17 μg/L and 0.026–0.03 mg/L		0.0035–3.5 mg/mL or 4.8 μg/mL	

Note: WHO = world health organizaton; WS = wholesale samples; RS = retail sales samples; MRL = maximum recommended limit; BLOD = below limit of detection; LOD = limit of detection (also note that chlorpyrifos was identify in the dichlorvos brand of pesticide used here according to *Ukpoko et al [2]* hence the two values were merged after determination and the mean values presented as a composite pesticide).

99 %, as demonstrated in the research by Soniya *et al.* and An-An Zhang [28, 29] in the case of pesticide elimination in fruits and vegetables.

3.5.4. Insecticides assessed in white maize foodstuffs

The samples of white maize collected from five markets were also assessed for three pesticides of the insecticide category. Pesticide was detected in all white maize samples collected, as shown in Table 5, while the Insecticide of dichlorvos with chlorpyrifos was detected in the entire white maize samples from North Bank Market and Wadata Market in different concentrations, whereas permethrin was not detected in any of the white maize samples.

Upon the analysis of white maize samples after treatment using principles of pesticides kinematic properties nexus to aqueous environments, aluminium phosphide was reduced below the method limit of detection after eliminated, while dichlorvos with chlorpyrifos in a wholesale sample from North Bank Market and Wadata Markets were reduced from 0.3489±0.002 to 0.0198±0.002 mg and 0.4440 ± 0.002 to 0.0100 ± 0.002 mg, respectively.

This experiment showed clearly that it is possible to eliminate pesticides in foodstuffs prior to cooking to a bearable minimum, using principles of kinematic properties of density, thermal volatility and solubility/ insolubility as kinematic properties of pesticides nexus to the aqueous environment.

The censored removal of pesticides, e.g., dichlorvos with chlorpyrifos, from wholesale samples could be due to the extent of sorption into the foodstuff materials and retention affinity under low temperature in storage, whereas in retail samples that are exposed to the sun for advertisements on sales points, they were almost eliminated below the validated detection limit, which suggested the effect of sun radiation upon exposure foodstuff may have enhanced the volatility of the dichlorvos with chlorpyrifos to evaporate, aiding the elimination treatment process rigor.

Table 5: Pesticides assessed in white beans before and after elimination using UV-spectrophotometer (mg/L) (continued).

Foodstuff sources	Aluminium phosphide (mg/L)		Dichlorvos & Chlorpyrifos (mg/L)		Permethrin (mg/L)	
White beans	Before	After	Before	After	Before	After
Highlevel Mkt (WS)	0.173±0.002	BLOD	0.3482±0.001	0.0201±0.001	BLOD	BLOD
Highlevel Mkt (RS)	0.138±0.002	0.0149±0.001	BLOD	BLOD	BLOD	BLOD
Modern Mkt (WS)	0.2183±0.003	BLOD	BLOD	BLOD	BLOD	BLOD
Modern Mkt (RS)	0.0089±0.001	BLOD	BLOD	BLOD	BLOD	BLOD
Northbank Mkt (WS)	0.3117±0.003	BLOD	0.3489±0.002	0.0198±0.002	BLOD	BLOD
Northbank Mkt (RS)	0.0079±0.000	BLOD	0.1537±0.001	BLOD	BLOD	BLOD
Wadata Mkt (WS)	0.3114±0.001	BLOD	0.4440±0.002	0.0100±0.002	BLOD	BLOD
Wadata Mkt (RS)	0.0107±0.001	BLOD	0.1547±0.001	BLOD	BLOD	BLOD
Wurukum Mkt (WS)	0.1191±0.002	BLOD	BLOD	BLOD	BLOD	BLOD
Wurukum Mkt (RS)	0.0182±0.001	BLOD	BLOD	BLOD	BLOD	BLOD
WHO MRL for grains foodstuff (mg/kg)	0.01–2 (0.01–0.05)		0.05–2.0		0.01–0.1	
Method limit of detection	0.005 to 0.1 mg/kg		0.05–0.17 μg/L and 0.026–0.03 mg/L		0.0035–3.5 mg/mL or 4.8 μg/mL	

Note: WHO = world health organizaton; WS = wholesale samples; RS = retail sales samples; MRL = maximum recommended limit; BLOD = below limit of detection; LOD = limit of detection (also note that chlorpyrifos was identify in the dichlorvos brand of pesticide used here according to *Ukpoko et al [2]* hence the two values were merged after determination and the mean values presented as a composite pesticide).

4. Conclusion

The research confirmed the presence of pesticides in grain foodstuffs, and it has reviewed the level of foodstuff sorption of pesticides, largely depending on direct and indirect application, among other factors. The concentration of the pesticides on foodstuffs in stores is relatively higher compared to retailers' displays under sun radiation for sales. The research also reviews that more than two pesticides are used in the preservation storage of same foodstuff at a time, though the elimination treatment method deals with multiple pesticide simultaneously to a bearable level. This experiment showed the possibility of eliminating pesticides in foodstuffs with treatments prior to cooking, using kinematic properties of density, thermal volatility and solubility of pesticides nexus to aqueous environments, similar to Soniya *et al.* and An-An Zhang *et al.* [28, 29] in the case of pesticide elimination in fruits and vegetables. The residual pesticide detected after elimination in some cases, e.g., dichlorvos with chlorpyrifos from wholesale samples, could be due to the extent of sorption into the foodstuffs' material and require a repeated elimination process to censored data content or total elimination of such foodstuffs.

This experiment showed the possibility of total elimination of pesticides in foodstuffs with treatments prior to cooking, using kinematic properties of density, thermal volatility and solubility of pesticides nexus to aqueous environments, similar to Soniya *et al.* and An-An Zhang *et al.* [28, 29] in the case of pesticide elimination in fruits and vegetables. The residual pesticide detected after elimination in some cases, e.g., dichlorvos with chlorpyrifos from wholesale samples, could be due to cool environment of storage and the extent of sorption into the foodstuffs' material considering storage duration, which require a repeatedly elimination treatment process to target total elimination in such foodstuffs.

Generally the report indicate that the method of elimination treatment reduced pesticides to a bearable minimum below instrument and methodology limit of detection and the cases that residues observe were within pesticide residual recommended limit by world health organization.

Data availability

The data used in this research is available and will be provided to the interest party on the request through the corresponding author.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this manuscript.

Funding

The authors received no specific funding from any public, commercial, or not-for-profit organisation for this research.

Acknowledgment

The authors hereby acknowledge and appreciate the cooperation of farmers from whom we got foodstuff free from pesticides and foodstuff dealers in Makurdi, Benue State, Nigeria.

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