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Analysis of some heavy metals in foodstuffs contaminated with pesticides using a developed spot-test method

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Abstract

The need for food security is a call for a simple and quick spot-test that can be used for the detection of contaminated grains and foodstuffs. Mostly, stored grain foodstuffs contained heavy metals due to metallic pesticides applied against pest infestation and environmental metallic contact during production processes. Foodstuffs samples of white beans, red Guinea corn, and white maize corn were purchased from five markets in Makurdi Town. Pesticide residues were extracted from the samples with hot, distilled, and deionized water in a pressure hot water extraction system (PHWES), respectively. The water extract was used to assess the presence of metallic pesticide contents of some heavy metals with the spot-tests developed. The results show that the water extract from grain foodstuffs contained Al, Fe, and Zn in almost all the samples. This could be a result of the predominant use of metallic pesticides like aluminium phosphide insecticide for the storage of grain foodstuffs. The spot-test developed is a simple and veritable technique for checking metallic pesticides as contaminants on/in foodstuffs at the preventive stage. This spot-test will help to curtail the consumption of metallic pesticides from grain foodstuffs.

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1. Introduction

The use of a wide range of inorganic pesticides on foodstuffs, on the field, and in stores has a negative effect on human health as well as the environmental contaminants [1]. Major sources of metal contaminations are industrial growth, volcanic eruptions, forest fires, corrosion, mining, sewage sludge, and agrochemicals [2]. The fate of metals contaminants is diverse. Metal sorbed in soil, contaminating water can be transferred to plants, which are then consumed by livestock or humans and can harm their wellbeing [2]. Recently agrochemicals of pesticides are the major sources of metals in postharvest foodstuff.

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A quality spot-test for the detection of metallic pesticides is necessary due to food production processes. The materials involved in foodstuffs production processes are sources of heavy metal contaminants [3, 4]. Nigeria, one of the biggest economies in Africa, with rapid growth in population, urbanization, agriculture, and industrial development, is experiencing the use of heavy metal materials in food storage. Hence there is a rising concern about grain foodstuff contamination with high metal concentrations [5, 6]. Research has shown that grains and foodstuffs have a significant amount of heavy metals from pesticide applications such as copper sulfate, ferrous sulfate, copper and sulfur, aluminum phosphide, etc. These metals are harmful to human health, the environment, and the economy due to improper treatment [7].

Pii *et al*. [8] reported that foodstuffs have many heavy metal ions that combine with nutrients and have the tendency to promote the growth of alien fungi species. These fungi exhibit invasive characteristics and threaten to cause harm to human health and the Nigerian economy [9]. These metallic contaminants from foodstuffs do metabolize and transform to products (TPs) of metallic contaminants, which are more toxic or biologically active than the parent contaminants [7, 10].

Grain foodstuffs have characteristics that define the natural state of safety as well as some physicochemical properties to identify the contaminated state, and these properties are mostly determined in the laboratory [11–14].

Spot-tests are recognized as the quick and simple veritable means for identification of matters [3, 15–18]. Hence, simple detection methods for contaminants of pesticides in foodstuffs have to be considered and developed to be applicable at the preventive stage. It is with these concerns that our research has developed a simple and veritable spot-test technique for checking metallic pesticides as contaminants on/in grain foodstuffs.

The presences of inorganic compounds or metals has called for development of a simple spot-test methods to determine metals in foodstuffs and water [19, 20] especially for heavy metals since some quality of water can be physically estimated with the help of simple spot-test [21].

Objectively, spot-tests developed aimed at quick and simple veritable means for identification of contaminants of heavy metals from pesticides on/in foodstuff. The reactions of spot-tests solution developed on known concentrations of the metals and the aqueous extract from foodstuff is valuable for on the spot identification of these heavy metals.

Spot-tests method of identification metals in foodstuff has significantly attested the presence of contaminants in foodstuff which required precaution measures on such foodstuff before consumption. These spot-tests are significant in context of public health precautions to curtail risk of foodstuff insecurity and regulatory compliance for food safety.

2. Materials and Methods

2.1. Foodstuffs sample collection

Foodstuffs sample of White Beans, Red Guinea Corn, and White Maize Corn were purchased from five markets in Makurdi Town. The samples were purchased in triplicate from whole sellers and retailers from each of the five major Markets. The samples were sealed tightly in plastic sample bottles to prevent interferences. The samples were taken to the chemistry laboratory, in Chemistry Department, Joseph Sarwuaan Tarka University Makurdi, for aqueous extraction of metallic pesticides and assessments consecutively.

2.2. Sample area

A survey and collection of storage food stuff was done in the five main markets shown on Figure 1, which is the Map of Makurdi Town in Benue State, Nigeria. These markets sites are shown with red spot alongside labels on the Map as follows: High level Market, Modern Market, North Bank Market, Wadata Market and Wurukum Market.

2.3. Preparation of a spot-test solution (T_1)

The weight of sodium hydroxide, 16 g (4 M), was dissolved in 100 mL of double-distilled and de-ionized water with a pH of 7.00; it was stopped and shaken until the solute dissolved completely. This solution could be used for a year.

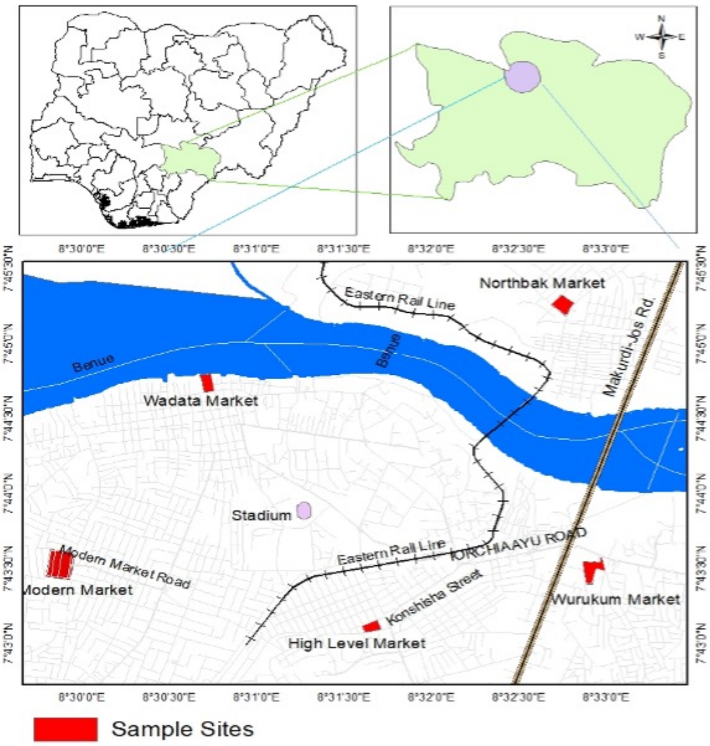

Figure 1: The map of Makurdi Town in Benue State, Nigeria.

2.4. *Watch glass aided spot-test for metallic pesticides in grains foodstuffs*

The respective metallic spike sample solutions were shaken; a graduated pipette was used to collect 0.2 mL of the solution, which was dropped on a watch glass of known weight (W_1), which was free of stains and any contamination. Also with a graduated pipette, 0.2 mL (0.32 g of spot-test) solution was dropped at the edge of the sample on the watch glass, and the reaction was observed, noting the nature of formations and colour(s) developed for identification. After the reaction was completed and the colour developed seemed to be faded or faint, it was observed at the edge of the colourless watch glass with the aid of shin rays or smart phone touch light at an angle of internal reflection on the solution (the phenomenal of total internal reflection of light through the solution on the glass intensify faded colours and magnified small formation to become obvious) to identify the metal's crystals and it colour.

For the quantitative gravimetric method, the formations/colours were noted, and they were allowed to dry at ambient temperature and reweighed (W_2) (if the formation seems to be hygroscopic, the oven dried at 40°C for 1 hour).

$$\text{Metal (s) estimation} = W_2 - W_1 = W_3. \tag{1}$$

Then

$$\text{Metal (s) per 0.2mL} = W_3 - 0.32g. \tag{2}$$

2.5. *Sensitivity identification of metals with spot-tests developed*

The analytical-grade heavy metals of concern, namely aluminum (Al), cadmium (Cd), cobalt (Co), chromium (Cr), copper (Cu), iron (Fe), mercury (Hg), manganese (Mn), nickel (Ni), lead (Pb), and zinc (Zn), were spiked in double-distilled and de-ionized water, respectively, at the standard concentrations of 0.05, 0.100, 0.200, 0.300, and 0.400 mg/L. The respective spike samples of metals prepared were determined with the gravimetric method, and the spot-test method developed. The two results were compared for sensitivity levels with algorithm concentration values as well as for method quality assurance.

2.6. Aqueous extraction of heavy metals on foodstuff and Identification

A foodstuff sample with matrix was loaded into the aqueous extractor system (AES) of 10-20 mL up to half and enclosed tightly. The aqueous extractor system containing the sample was filled with the extraction solvent of double-distilled and deionized hot aqueous (45–85 ^oC) from a water flask to immerse the sample using a 10 mL syringe. The contents were gently shaken for five (5) minutes and rubbed in palms to build in pressure and maintain the temperature in the system for at least five minutes to make it a pressure hot water extraction system (PHWES) [22]. This is because metals dissolving process is endothermic, hence metals solubility increases with an increased in temperature and pressure in water.

Altering the physicochemical properties of water helps to improve its efficiency as the predominant solvent for the extraction of natural and synthetic products because, at some ambient temperatures, water is highly polar with a high dielectric constant. As water is heated, its permittivity, viscosity, and surface tension decrease significantly, while its diffusion increases as the temperature increases [22]. Hence, at elevated temperatures and pressures, water displays properties to enable it to extract metals within a wide range of molar solubility effectively [22]. Pressure influences diffusion of water as an extraction feature positively by penetrating and detaching the metals weak binding on foodstuffs into solution.

Then AES with the blank of PHWES are compared; the observations and inferences were recorded and compared for a preliminary spot-test. The extract was then used to determine metals on a glass-aided spot-test developed for inorganic contaminants in grains and foodstuffs. AES was flushed with hot distilled and deionized water to dissolve and remove any remaining contaminants from the sample, followed by a flush with methanol to be reused.

3. Results and discussion

3.1. Spot-test developed

Spot-test solution T_1 was developed and used for qualitative identifications of some metallic pesticide contaminants of Al, Cd, Co, Cr, Cu, Fe, Hg, Mn, Ni, Pb, and Zn in aqueous extract from on/in grain foodstuffs. The sensitivity of these spot-tests developed gave significant responses to the target analytes. This spot-test for peculiar heavy metals of popular contaminants in grain foodstuffs is very simple, and it is also very efficient for qualitative analysis of heavy metals in grain foodstuffs samples. With the aid of white glass internal reflection of light on solution, this technique detects some metals quantitatively as low as 0.1 mg/L in samples of water as described in the method on Table 1 and the sensitivity result on Table 2. There are some spot-tests for metal identification but are mainly conducted in laboratories [17]. Recently, a tabletop and handheld NEX CG II Series bring a new level of analytical sensitivity to XRF technology, which can measure ultra-low and trace metals (elements) for qualitative and quantitative concentrations, even in challenging sample types. It has many advantages for metals analysis but is very expensive to afford. The developed spot-test with solution T_1 is a quick, easy, inexpensive, dependable, tough, safe, and reproducible analytical method to be adopted by consumers for qualitative-oriented results for precautionary measures.

3.2. Calibration, sensitivity and standardization of spot-test developed compared to conventional method

The stock solutions were used to prepare serial dilutions of algorithm values from 0.05 to 0.4 mg/kg, which was used in searching for response surfaces effectiveness and efficacies by one factor at a time optimization system from a minima value with the spot-test and the gravimetric analysis. The sensitivity standard was observed by comparing the minimal and differences in values at which each spike heavy metal was detected by these methods. This process ensured method calibration, standard sensitivity levels, and quality assurance of heavy metal levels of detection by the spot-tests developed.

The total numbers of heavy metal contaminants involved in the study were eleven (11); four metals of Cd, Co, Cu, and Ni were not detected by the spot-test developed at a standard concentration spike of 0.050 mg/kg. On a standard algorithm concentration spike of 0.100 mg/kg, nine of the heavy metals were detected with spot-test solution T_1 except Ni and Cu. Spot-test solution T_1 detected all the metals of Al, Cd, Co, Cr, Cu, Fe, Hg, Mn, Ni, Pb, and Zn at the algorithms standard concentration spike values of 0.200 mg/kg, respectively. The gravimetric method detected the presence of all eleven metals spike at all the algorithm values but gave less values compared to the respective standard concentration values prepared. The differences in values obtained from the gravimetric method and the value of metal spike could be as a result of some factors, like incomplete equilibrium of reactants, reaction factors, impurities in material used for standard, drift in the analytical balance, and other possible factors. The researchers' sole aim of detecting heavy metal contaminants in grain foodstuffs at a least value is achieved with the aid of the qualitative

Table 1: The results of qualitative spot-test methods for some heavy metals.

Test with Solution T_1 0.2 mL		Observation	Influence	Metals
1	0.2 mL Spike H_2O + T_1	Grey alloy floating on the solution		Al^{3+}
2	0.2 mL Spike H_2O + T_1	White particle insoluble becomes fine dust settle down on swinging	Metal Contaminants	Cd^{3+}
3	0.2 mL Spike H_2O + T_1	Reddish-pink ppt soluble forms	Metal Contaminants	Co^{2+}
4	0.2 mL Spike H_2O + T_1	Green ppt soluble	Metal Contaminants	Cr^{3+}
5	0.2 mL Spike H_2O + T_1	Light blue ppt	Metal Contaminants	Cu^{2+}
6	0.2 mL Spike H_2O + T_1	Brown yellow ppt soluble evolved slowly	Metal Contaminants	Fe^{3+}
7	0.2 mL Spike H_2O + T_1	Light green ppt soluble evolved slowly	Metal Contaminants	Fe^{2+}
8	0.2 mL Spike H_2O + T_1	Brown insoluble ppt formed sharply and settle down	Metal Contaminants	Hg
9	0.2 mL Spike H_2O + T_1	Blue-green ppt evolved	Metal Contaminants	Mn
10		Magenta soluble ppt		Mn^{7+}
11	0.2 mL Spike H_2O + T_1	Light green ppt soluble	Metal Contaminants	Ni^{2+}
12	0.2 mL Spike H_2O + T_1	White-grey ppt insoluble settle down	Metal Contaminants	Pb
13	0.2 mL Spike H_2O + T_1	Purple insoluble ppt	Metal Contaminants	Ti^{3+}
14	0.2 mL Spike H_2O + T_1	Purple soluble ppt	Metal Contaminants	V^{2+}
15	0.2 mL Spike H_2O + T_1	White, colloid ppt insoluble forms	Metal Contaminants	Zn

Note: T_1 is the spot-test solution, ppt. is precipitation.

spot-tests developed, whereby all the metals were detected below WHO [1] indicative maximum permissible limit, respectively, as shown on Table 2.

3.3. Verification of spot-tests sensitivity and standardisation

Sensitivity and standard verification for method reproducibility was done by verifying the method's reproducibility within acceptable precision and accuracy of results. This was achieved by repeating the same procedures in triplicate (or more times) in each stage in all cases. The result values were analyzed using IBM SPSS Statistic software for the analysis of mean and standard deviation as shown on Table 2, respectively. The qualitative results from the developed spot-tests have similar precision results compared to the gravimetric method as the conventional method. The spot-tests developed are mainly qualitative and is sensitive on samples that the quantitative conventional method have shown positive results and vice versa.

3.4. Spot-test qualitative assessments of metallic contaminants in grains foodstuff

Heavy metal contaminants from pesticides were assessed in three foodstuffs of white beans, red guinea corn, and white maize from five markets in Makurdi with spot-test methods developed for metallic pesticides in water extract presented on Table 3.

3.4.1. The metallic pesticides contaminants assessed in white beans foodstuff

The inorganic contaminants of heavy metals from pesticides found in the white bean sampleware Al, Fe, and Zn were detected in both store wholesale and retail samples from High Market, Modern Market, Wadata Market, and Wurukum Market in different concentrations except Northbank Market, as shown on Table 3.

Table 2: Calibration, sensitivity and standard of spot-test solution T_1 compared to conventional method on contaminants.

Metals	FAO/WHO MPV (mg/kg)	Method	Algorithms (mg/kg)				
			0.050	0.100	0.200	0.300	0.400
Al	1.000	Qualitative	T_1^-	T_1^+	T_1^+	T_1^+	T_1^+
		Quantitative	0.0203±0.0001	0.0250±0.0010	0.0702±0.0011	0.1040±0.0010	0.2210±0.0014
Cd	0.003	Qualitative	BD	T_1^+	T_1^+	T_1^+	T_1^+
		Quantitative	0.0077±0.0010	0.0101±0.0008	0.0395±0.0014	0.1333±0.0023	0.1911±0.0017
Co	0.100	Qualitative	BD	T_1	T_1^+	T_1^+	T_1^+
		Quantitative	0.0011±0.0011	0.0014±0.0003	0.1060±0.0010	0.1910±0.0013	0.2850±0.0009
Cr	0.005	Qualitative	T_1^-	T_1^+	T_1^+	T_1^+	T_1^+
		Quantitative	0.0068±0.0009	0.0914±0.0020	0.1072±0.0021	0.2012±0.0011	0.3107±0.0013
Cu	73.300	Qualitative	BD	BD	T_1^+	T_1^+	T_1^+
		Quantitative	0.0014±0.0012	0.0512±0.0004	0.0903±0.0005	0.1914±0.0012	0.2911±0.0022
Fe	425.500	Qualitative	T_1^-	T_1^+	T_1^+	T_1^+	T_1^+
		Quantitative	0.0083±0.0001	0.0701±0.0006	0.1203±0.0008	0.2903±0.0005	0.3203±0.0031
Hg	0.010	Qualitative	T_1^-	T_1^+	T_1^+	T_1^+	T_1^+
		Quantitative	0.0462±0.0022	0.0910±0.0010	0.1151±0.0016	0.2253±0.0013	0.3146±0.0011
Mn	0.200–0.400	Qualitative	T_1^-	T_1^-	T_1^+	T_1^+	T_1^+
		Quantitative	0.0015±0.0011	0.0481±0.0011	0.0933±0.0013	0.1939±0.0010	0.2933±0.0014
Ni	47.900	Qualitative	BD	BD	T_1^+	T_1^+	T_1^+
		Quantitative	0.0111±0.0019	0.0201±0.0010	0.0078±0.0010	0.1218±0.0011	0.2046±0.0010
Pb	0.300	Qualitative	T_1^-	T_1^-	T_1^+	T_1^+	T_1^+
		Quantitative	0.0325±0.0021	0.0904±0.0021	0.1803±0.0011	0.2213±0.0010	0.3102±0.0011
Zn	99.400	Qualitative	T_1^-	T_1^+	T_1^+	T_1^+	T_1^+
		Quantitative	0.0382±0.0015	0.0821±0.0013	0.1522±0.0010	0.3599±0.0011	0.3822±0.0011

Note: T_1 is the spot-test solution, T_1^+ is positive test result, T_1^- is negative test result.

3.4.2. The metallic pesticides contaminants assessed in red guinea corn foodstuff

The amount of heavy metal contaminants from pesticides present in the Red Guinea Corn sampleware was Al, Fe, and Zn and were detected in both store wholesale and retail samples from High Market, Modern Market, and Wurukum Market in different concentrations except Wadata Markets and Northbank Market, as the result presented in Table 3.

3.4.3. Metallic pesticides assessed in white maize corn foodstuff

The heavy metal contaminants found in the white maize corn sample from High Market, Modern Market, Northbank Market, Wadata Markets, and Wurukum Market were Al, Fe, and Zn. These heavy metals were qualitatively detected in both store wholesale and retail samples in different concentrations.

3.5. Health and environmental implications

Human skin contact with aluminum phosphide causes skin irritation. Breathing in aluminum phosphide can irritate the nose, throat, and lungs, causing coughing, wheezing, and shortness of breath. Prolonged intake of aluminum phosphide damaged the lungs, kidneys, and liver [1].

Zinc has many health benefits, but too much intake of zinc can cause dizziness, headaches, upset stomachs, and loss of appetite. Long-term high intake can lead to lower immunity, low HDL cholesterol, and low copper levels in the body system [1].There is no level of exposure to lead that is known to be without harmful effects, especially young children who are vulnerable to the toxic effects of lead and can suffer permanent adverse health impacts, particularly on the development of the central nervous system. Lead causes long-term harm in adults, including increased risk of high blood pressure, cardiovascular problems, and kidney damage. Lead exposure during pregnancy can cause reduced fetal growth and preterm birth [2]. WHO is preparing guidelines on prevention of heavy metal exposure, which will provide policymakers, public health authorities, and health professionals with evidence-based guidance on the measures to protect the health of children and adults from heavy metal exposure. The harmful impacts on health and the environment from heavy metal exposure are entirely preventable with the aid of a spot-test developed to identify and eliminate it appropriately.

Table 3: Qualitative assessments of metallic contaminants in foodstuff with spot-test

	Samples / Area High level Mkt	Point collected	Al	Cd	Co	Cr	Cu	Fe	Hg	Mg	Ni	Pb	Zn
1	White Beans	Stores	+++	–	–	–	–	+	–	–	–	–	++
		Retails	+	–	–	–	–	–	–	–	–	–	+
	RedGuinea corn	Stores	++	–	–	–	–	+	–	–	–	–	+
		Retails	+	–	–	–	–	–	–	–	–	–	+
	Maize corns	Stores	++	–	–	–	–	+	–	–	–	–	+
		Retails	++	–	–	–	–	–	–	–	–	–	+
2	Modern Mkt												
	White Beans	Stores	++	–	–	–	–	+	–	–	–	–	+
		Retails	+	–	–	–	–	–	–	–	–	–	–
	RedGuinea Corn	Stores	++	–	–	–	–	–	–	–	–	–	+
		Retails	+++	–	–	–	–	+	–	–	–	–	++
	Maize Corn	Stores	++	–	–	–	–	+	–	–	–	–	+
		Retails	+	–	–	–	–	++	–	–	–	–	++
3	North Bank Mkt												
	White Beans	Stores	–	–	–	–	–	–	–	–	–	–	–
		Retails	–	–	–	–	–	–	–	–	–	–	–
	RedGuinea Corn	Stores	–	–	–	–	–	–	–	–	–	–	–
		Retails	–	–	–	–	–	–	–	–	–	–	–
	Maize Corn	Stores	+	–	–	–	–	++	–	–	–	–	++
		Retails	++	–	–	–	–	+	–	–	–	–	++
4	Wadata Mkt												
	White Beans	Stores	++	–	–	–	–	+	–	–	–	–	+++
		Retails	++	–	–	–	–	+	–	–	–	–	++
	RedGuinea Corn	Stores	–	–	–	–	–	–	–	–	–	–	–
		Retails	–	–	–	–	–	–	–	–	–	–	–
	Maize Corn	Stores	++	–	–	–	–	+	–	–	–	–	+
		Retails	++	–	–	–	–	+	–	–	–	–	+
5	Wurukum Mkt												
	White Beans	Stores	+++	–	–	–	–	+	–	–	–	–	+
		Retails	++	–	–	–	–	++	–	–	–	–	+
	RedGuinea Corn	Stores	+++	–	–	–	–	++	–	–	–	–	+
		Retails	++	–	–	–	–	+	–	–	–	–	++
	Maize Corn	Stores	+++	–	–	–	–	++	–	–	–	–	–
		Retails	++	–	–	–	–	+	–	–	–	–	+

Note: – is negative test result, + one sample is positive, ++ is two are samples positive and +++ is three are sample positive

3.6. Limitations and future research directions

The acknowledgement study was limited to three grain foodstuffs of white beans, white maize, and red guinea corn only, and the spot-tests were developed for only eleven heavy metals. The conventional method was used for spot-test sensitivity and standardization sensitivity across different metal types but was not applicable in assessing the heavy metal contaminants in foodstuffs for comparison.

The lessons learned from this research on comparison of spot-test developed and the conventional methods include: (1) Foodstuff and water contaminants with metallic pesticides is a worldwide phenomenon, with sources mainly deriving from human activities; (2) treatment does not necessarily mean complete removal of contaminants; (3) some of this metal pollutants can come from metabolites and transformed products (TPs) of contaminants matters because some can be more toxic or biologically active than the parent contaminants; (4) The unconventional testing of the toxicity and effects are needed for foodstuffs, water and ecological emerging contaminants (This will help to account for ecological toxicity when present in foodstuff as mixtures). (5) It is obvious that even the most advanced tools can miss the target (may be due to the lack of standards and searchable library scope of the methods or instruments).

We suggest future research should try additional metals, expanding the range of foodstuff types, or validating the spot-test method in real-world field conditions. Also, both the spot-tests developed and the conventional method should be applicable in assessing the heavy metal contaminants in foodstuffs samples for comparison.

4. Conclusion

The application of a wide range of metallic pesticides on foodstuffs in the field and in stores has a negative effect on human health and the environment. The demand for quality spot-tests for detection of metallic pesticides in grain foodstuffs is necessary due to food storage and many processes that involved sources of heavy metal contaminants. Spot-test solution T_1 was developed and is sensitive to all the metals of Al, Cd, Co, Cr, Cu, Fe, Hg, Mn, Ni, Pb, and Zn at the standard concentration of 0.200 mg/kg, respectively, whereas the gravimetric method determination result gave less values compared to the respective standard concentrations prepared. The small differences between the results of the gravimetric method and the values of the standard concentrations prepared could be as a result of some factors like incomplete equilibrium of reactants, impurities in material used for the standard, drift in the analytical balance, and other reaction factors. The sensitivity results from both the gravimetric method and the spot-test method on Table 2 were synonymous, which is an indication that the spot-test developed is sensitive and applicable.

Using the spot-test developed, inorganic contaminants of heavy metals from pesticides were found in almost all the samples, including Al, Fe, and Zn, and were detected in both store wholesale and retail samples from High Market, Modern Market, Northbank Market, Wadata Markets, and Wurukum Market in different concentrations, except in some Red Guinea Corn samples from Northbank and Wadata Markets. This could be attributed to the high application of aluminum phosphide insecticide for storage of foodstuffs in those markets. Aluminium phosphide is inserted into the bags directly or by wrapping in tissue paper before inserting into the foodbags or containers, which, on mechanical shacking, breaks it, leaving its powder in contact with the food. Aluminum phosphide is the most used insecticide for food storage in Benue State currently. This spot-test will help to curtail the consumption of metallic pesticides from grain foodstuffs. Now foodstuffs could be stored massively with pesticides, but with the aid of these veritable spot-tests developed, we can detect and eliminate metallic pesticides through pre-treatment to improve food safety before consumption.

Data availability

The data is available and can be released by the corresponding author on request under special terms and conditions.

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