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Full Length Research Paper

Human health risk assessment on the consumption of *Musa acuminata* treated with different ripening agents

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ABSTRACT: The use of indiscriminate ripening agents (e.g., Calcium Carbide) to improve fruit ripening exposes fruits to heavy metal contamination, which can have long-term health consequences for consumers. The purpose of this study was to determine the heavy metals levels of albino rats fed *Musa acuminata* treated with different ripening agents and also to ascertain through probabilistic models and United States Environmental Protection Agency (USEPA) standards, the extent of health risk and carcinogenicity to the consumers. Twenty-five (25) female albino rats were acclimatized for two weeks after which they were divided into five groups. Group 1 (Normal feed and water), Group 2 (feed + 20g of naturally ripened banana), Group 3 (Feed + 20g of banana ripened with African bush mango), Group 4 (Feed + 20g of banana ripened with 7g calcium carbide), Group 5 (Feed + 20g of banana ripened with 30g calcium carbide). The levels of Arsenic (As), Lead (Pb), and Chromium (Cr) were determined using atomic absorption spectrophotometer. The result showed an increase in the levels of Pb and As for groups 2, 3, 4, and 5. Groups 4 and 5 for Cr were significantly higher ($p < 0.05$). Results from the human health risk assessment model for Estimated Daily Intake showed an increase above the tolerable daily intake for heavy metals such as Pb (for groups 2, 3, 4, and 5) and As (for group 5). There was also a fall in the Tolerable daily intake (TDI) for Cr (all groups were below the TDI) and As (for groups 1, 2, 3, and 4). Toxic Hazard Quotient (THQ) showed increased values above the standard THQ ($0<x<1$) for an acceptable human such as Pb (for groups 2, 3, 4, and 5) and As (for group 5), whereas values for Cr and As (for group 1, 2, 3 and 4) were below the standard THQ. Carcinogenic Risk (CR) values showed that all values estimated were within the value of USEPA incremental lifetime carcinogenic risk (ILCR > 10^{-3}) while As for group 5 was otherwise. The observed results showed that calcium carbide contains traces of potential toxic elements (heavy metals) and that its use in fruit ripening will pose a potential health risk on the consumers.

Keywords: Risk assessment, heavy metals, carcinogenic risk, calcium carbide, fruit ripening

INTRODUCTION

In recent years, the use of artificial fruit ripening agents has increased for commercial reasons (Nazibul et al., 2018). To begin the ripening process in fruits such as bananas, various ripening agents are used. Fruit ripening is a natural process in which the fruit transforms physically and chemically to become sweeter, more colorful, softer, and more pleasant (Kendrick, 2012). The use of artificial ripening agents assists fruit sellers in meeting consumer demands because they provide a faster ripening time (Dhembare, 2013). Among all ripening agents, calcium carbide is the most commonly used chemical for artificial ripening because it is inexpensive, effective, and easily obtained in local markets (Asif, 2012).

Most artificial ripening agents, on the other hand, are dangerous and carcinogenic, and their ingestion can lead to major health problems like heart disease, skin illness, lung failure, and renal failure, among other things.(Hakim et al., 2012). Impurities in artificial ripening agents include arsenic (As), lead (Pb), cadmium (Cd), and chromium (Cr), which are non-essential elements that are not required for biological function and may be harmful to human health (Basapor and Ngabaza, 2015). Consumption of artificially ripened bananas raises public health concerns because potentially toxic elements bio-accumulate in the systems of most organisms and bio-magnify over time (Orisakwe et al., 2012), disrupting various biological processes in the body. The ability of the human defense mechanism, such as antioxidants, to combat these toxic element exposures may deteriorate with repeated exposure, stimulating a disease condition or exacerbating some health risk condition (Hamlet et al., 2012).

An evaluation process is used to assess the health effects of chemicals in order to reach a scientific consensus on the dangers of chemical exposure (WHO, 2011). A health risk assessment study seeks to quantify the consequences of human activities and weigh the negative impact on public health against the benefits to economic growth. Risk assessment's role is to conduct the study, estimate the risk, and forecast how it will change as a result of various causes of action, as well as guide the form of precedents, thresholds, comparisons, and lateral solutions. These can then be developed further and distributed to interested parties and stakeholders. It is currently one of the quickest methods for assessing the impact of hazards on human health (Yujunet al., 2011).

For a chemical pollutant, the Estimated Daily Intake (EDI) indicates the average person's overall exposure from all known or suspected exposure pathways. It is the highest dose of a chemical that can be consumed daily for the rest of one's life without posing a significant health risk; it is based on the highest dose that does not cause noticeable side effects (Bamuwamye et al., 2015). When calculating the estimated daily intake, the result is compared to the tolerable daily intake (TDI), and an inference is drawn. It is important to note that the estimated daily intake for adults and children differs (Reham et al., 2013).

The toxic hazard quotient (THQ) is the ratio of toxic element exposure to the reference oral dose (RfD), which is the highest level at which no adverse health effects are expected ((Johann et al., 2017). The reference oral dose is usually tailored to the trace element under consideration. The THQ identifies the hazardous element's non-carcinogenic health risk. Non-carcinogenic health effects are not expected if the THQ is less than one (< 1), no adverse health effect is expected. If the THQ is greater than one (> 1), there is a chance that adverse health effects will occur. A THQ greater than one, does not always indicate a statistically significant likelihood of adverse non-carcinogenic health effects (Onuoha et al., 2016).

The target cancer risk (TCR) is used to calculate the potential risk associated with an individual's lifetime exposure to carcinogenic agents (Liang et al., 2017). When assessing cancer risk, carcinogenic slope factor (CSF) is used instead of the oral reference dose used in the determination of THQ. The carcinogenic slope factor (Table 1) is used to estimate the likelihood of cancer risk over the lifetime of the exposed individual. It is a toxicity value that quantifies the dose-response relationship. The cancer slope factor is a reasonable upper-bound estimate of an individual's likelihood of developing cancer after being exposed to a chemical for 70 years (Bamuwamye et al., 2015; Onuoha et al., 2016). Cancer slope factors for ingestion are commonly expressed in milligrams per kilogram per day (mg/kg/day). The purpose of this study was to determine the heavy metals levels of albino rats fed *Musa acuminata* treated with different ripening agents and also to ascertain through probabilistic models and United States Environmental Protection Agency (USEPA) standards, the extent of health risk and carcinogenicity to the consumers.

MATERIAL AND METHODS

Plant material

Freshly harvested Unripe but matured banana fruits were purchased from Obollo Afor market in Nsukka, Enugu State, and Southeastern Nigeria. The ripening agent (African Bush Mango) used for the study was also bought from the same market.

Animals

Twenty-five (25) albino rats (female) with a weight ranging from 120-150 grams were used for the study. The animals used were obtained from the animal house of the Department of Veterinary Medicine, University of Nigeria Nsukka. They were separated into groups of 5 using an aluminum cage. The experimental animals were given two (2) weeks to acclimate in a suitable environment, and they were fed standard growers mash with clean water before being given the banana flour.

Reagents and chemicals

All chemicals used in this study were of analytical grade.

Instruments and equipment

The instrument used includes Atomic Absorption Spectrophotometer (model AA-7000 Shimadzu, Japan ROM version 1.01, S/N A30664700709), weighing balance, and animal cage.

METHODS

Sample preparation

The banana fruits were carefully separated from the bunch, washed with clean water, and subjected to different ripening methods. They were cut and separated

Table 1: Ingestion Reference Dose (IRD).

Heavy metals	Ingestion Reference Dose (mg/kg/day)	Carcinogenic slope factor (mg/kg/day)
Arsenic (As)	0.0050	1.5000
Chromium (Cr)	1.5000	0.5000
Lead (Pb)	0.0035	0.0085
Nickel (Ni)	0.0200	1.7000

Source: (Bamuwamye *et al*., 2015; Onuoha *et al*., 2016)

Table 2: Treatment groups.

Groups	Treatments
Group 1	Received normal feed and water
Group 2	Received 20 g of naturally ripened banana
Group 3	Received 20 g of banana ripened with African bush mango
Group 4	Received 20 g of banana ripened with 7 g calcium carbide
Group 5	Received 20 g of banana ripened with 30 g calcium carbide

into 4 groups made up of fourteen (14) banana fingers of approximately the same size each. Each of the four ripening methods was replicated five times. The banana samples were kept in clean polyethylene bags and treated with different ripening agents to induce the ripening process. Batch A was allowed to ripen naturally, batch B was ripened using African bush mango, and batch C & D were ripened using 7 g and 30 g of calcium carbide respectively. The stage of ripening of the fruit was considered to be a change in the skin color and texture of the fruit. After ripening was achieved, the fruits were peeled, sliced, and dried in a hot-air oven. The dried fruits were pulverized using a mechanical grinder and stored in plastic containers. The dried banana samples were mixed with the animal feed and administered to the animals.

Treatment

Twenty-five (25) albino rats were used. The animals were randomly divided into five (5) main experimental groups, each containing five (5) animals. After two weeks of acclimatization, 20 g of the pulverized banana was mixed with the rats' feed and served to them for thirty days (Table 2).

Collection of blood sample from experimental animals

After 30 days of the administration, the animals were sacrificed. Blood samples were collected through occular puncture using anticoagulant bottles for heavy metal analysis.

Heavy metal studies

Each of the samples was weighed into the digestion flask, and 30 cm^3 of aqua regia (a mixture of HNO_3 and HCl in a 1:3 ratio) was added and digested in the fume cupboard until a clear solution was obtained. It was cooled, filtered, and then made up to 50 ml in a standard volumetric flask with de-ionized water. The digested samples were analyzed for Arsenic (As), Chromium (Cr), Lead (Pb), using atomic absorption spectrophotometer (AAS) at respective wavelengths. A blank sample was prepared to zero the instrument before running another series of samples. Standards (2 ppm, 4 ppm, and 6 ppm) were prepared from 1000 ppm stock solution of the metals and used to plot the calibration curve. The curve was plotted automatically by the instrument. Atomic Absorption Spectrometer (model AA-7000 Shimadzu, Japan ROM version 1.01, S/N A30664700709) was used for the analysis (Gray, 1980).

Statistical analysis

All experiments were done in replicate. The data obtained were analyzed using International Business Machines Corporation (IBM) Statistical Product and Service Solution (SPSS) version 20.0 and Microsoft Excel 2010. The results were expressed as mean ± standard deviation (SD). One way analysis of variance (ANOVA) was carried out as $p < 0.05$ and was considered statistically significant. Duncan's Multiple Range Test (DMRT) was used to compare mean values.

Human health risk assessment

Estimated daily intake (EDI)

The estimated Daily Intake of metals for adults and children was determined by the equation

$$\mathrm{EDI} = \frac{\text{Concentration of Metals X Daily Banana Intake}}{\text{Average Body Weight}}$$

Table 3: Heavy metal content of albino rats fed *Musa acuminata* treated with different ripening agents.

Treatments	Pb (mg/kg)	Cr (mg/kg)	As (mg/kg)
Group1	0.25 ± 0.00^{a}	0.05 ± 0.01^{a}	0.06 ± 0.01^{a}
Group 2	0.50 ± 0.00^{b}	0.06 ± 0.00^{a}	0.09 ± 0.00^{bc}
Group	0.50 ± 0.00^{b}	0.06 ± 0.00^{a}	0.08 ± 0.01^{ab}
Group 4	0.75 ± 0.00^{c}	0.12 ± 0.00^{b}	0.11 ± 0.01^{c}
Group 5	1.08 ± 0.08^{d}	0.16 ± 0.01^{c}	1.23 ± 0.14^{d}

Results expressed in means ± SD, n = 3. Values in the same column having different superscripts differ significantly (P < 0.05). Pb = Lead, Cr = Chromium, As = Arsenic. Group 1 = Received normal feed and water, Group 2 = Received 20g of naturally ripened banana, Group 3 = Received 20g of banana ripened with African bush mango, Group 4 = Received 20g of banana ripened with 7g calcium carbide, 5 = Received 20g of banana ripened with 30g calcium carbide.

Table 4: Estimated daily intake (EDI) of heavy metal through the consumption of banana treated with different ripening agents as compared to the tolerable daily intake (TDI).

Treatments	Pb (mg/kg/day)		Cr (mg/kg/day)		As (mg/kg/day)	
	Children	Adult	Children	Adult	Children	Adult
Group1	0.0025	0.0017	0.0005	0.0003	0.0006	0.0004
Group 2	0.0050	0.0033	0.0006	0.0004	0.0009	0.0006
Group 3	0.0050	0.0033	0.0006	0.0004	0.0008	0.0005
Group 4	0.0070	0.0050	0.0012	0.0008	0.0011	0.0007
Group 5	0.0108	0.0072	0.0016	0.0011	0.0123	0.0082
TDI	0.0036		0.1500			0.0021

TDI = Tolerable daily intake. Group 1 = Received normal feed and water, Group 2 = Received 20g of naturally ripened banana, Group 3 = Received 20g of banana ripened with African bush mango, Group 4 = Received 20g of banana ripened with 7g calcium carbide, 5 = Received 20g of banana ripened with 30g calcium carbide.

Toxic hazard quotient (THQ)

Toxic Hazard Quotient was calculated using the equation below

$$THQ = \frac{\text{Concentration of Metals X Daily Banana Intake}}{\text{RfD x Average Body Weight}}$$

Where RfD is the Oral Reference Dose (Onuoha *et al.*, 2016)

Carcinogenic risk (CR)

The lifetime probability of cancer or carcinogenic risk was estimated according to USEPA, (2017).

CR = Estimated Daily Intake (mg/kg/day) x Ingestion Carcinogenic Slope Factor (mg/kg/day)-1.

RESULTS

Results from (Table 3) for albino rats fed banana treated with different ripening agents showed a significant increase ($p < 0.05$) in the level of Lead (Pb) and Arsenic (As) for groups 2, 3, 4, and 5 when compared with group 1. However, groups 4 and 5 for Chromium were significantly higher when compared with group 1 while groups 2 and 3 showed no significant difference ($p < 0.05$).

Human health risk assessment

Estimated daily intake (EDI)

Results from the human health risk assessment model for Estimated Daily Intake as seen in (Table 4) showed an increase above the tolerable daily intake for heavy metals such as Pb (for groups 2, 3, 4, and 5) and As (for group 5). There was also a fall in the Tolerable daily intake for

Table 5: Toxic hazard quotient (THQ) of heavy metals through the consumption of bananas treated with different ripening agents.

Treatments	Lead		Chromium		Arsenic	
	Children	Adult	Children	Adult	Children	Adult
Group1	0.7143	0.4857	0.0003	0.0002	0.1200	0.0800
Group 2	1.4286	0.9429	0.0004	0.0003	0.1800	0.1200
Group 3	1.4286	0.9429	0.0004	0.0003	0.1600	0.1100
Group 4	2.1429	1.4286	0.0008	0.0005	0.2200	0.1500
Group 5	3.0857	2.0571	0.0012	0.0007	2.4600	1.6400

Group 1 = Received normal feed and water, Group 2 = Received 20g of naturally ripened banana, Group 3 = Received 20g of banana ripened with African bush mango, Group 4 = Received 20g of banana ripened with 7g calcium carbide, 5 = Received 20g of banana ripened with 30g calcium carbide.

Table 6: Carcinogenic risk of heavy metal through the consumption of bananas treated with different ripening agents.

Treatments	Lead		Chromium		Arsenic	
	Children	Adult	Children	Adult	Children	Adult
Group1	2.1E-5	1.4E-5	2.5E-4	1.5E-4	9E-4	6E-4
Group 2	4.3E-5	2.8E-5	3E-4	2E-4	1.4E-3	9E-4
Group 3	4.3E-5	2.8E-5	3E-4	2E-4	1.2E-3	8E-4
Group 4	6.4E-5	4.3E-5	6E-4	4E-4	1.7E-3	1.1E-3
Group 5	9.2E-5	6.1E-5	8E-4	5.4E-4	1.8E-2	1.2E-2

Group 1 = Received normal feed and water, Group 2 = Received 20g of naturally ripened banana, Group 3 = Received 20g of banana ripened with African bush mango, Group 4 = Received 20g of banana ripened with 7g calcium carbide, 5 = Received 20g of banana ripened with 30g calcium carbide.

Cr (all groups were below the TDI) and As (for groups 1, 2, 3, and 4).

Toxic hazard quotient

Results from the human health risk assessment model for Toxic Hazard Quotient (Table 5) showed increased values above the standard THQ ($0 < x < 1$) for an acceptable human such as Pb (for groups 2, 3, 4, and 5) and As (for group 5), whereas values for Cr and As (for groups 1, 2, 3 and 4) were below the standard THQ, thus being within the acceptable range. The results also showed that children were more at risk than adults.

Incremental lifetime carcinogenic risk (ILCR)

Carcinogenic Risk (CR) values from the human health risk assessment mode (Table 5) showed that all values estimated were within the value of USEPA incremental lifetime carcinogenic risk (ILCR > 10^{-3}) having more than 1 cancer case per 10,000 persons. However, CR values were within an acceptable range (10^{-3}< ILCR <10^{-6}) while Arsenic for group 5 was otherwise**.**

DISCUSSION

This study investigated different banana ripening methods and how their consumption could affect human health. The results from (Table 3) present the heavy metal results of rats fed with banana treated with different ripening agents. Heavy metals such as Lead (Pb), Arsenic (As), and Chromium (Cr) are considered toxic contaminants making their importance in the body insignificant. Rats which served as control had the lowest concentration of Pb, while carbide ripened bananas had the highest values. The values for rats fed the naturally ripened bananas with no ripening agent and the biological agents (African bush mango) were almost the same but differed significantly when compared to the control. Though the Pb values increased when carbide ripened bananas were fed to the rats, Pb values for both the naturally and artificially ripened were higher than the permissible limits of 0.003 ppm for fruits (Orisakwe *et al*., 2012). The presence of Pb in the fruit may be from the soil as high levels of Pb have been reported in different farmlands in Eastern Nigeria (Orisakwe and Ajaezi, 2014) and in fruits like banana, apple, and pineapple (Sobukola *et al*., 2010). Also, the presence of Pb detected in the ripened bananas could be due to the type of ripening agent, storage/packaging material used during ripening (Sajib *et al*., 2014), also Banadda *et al*. (2011) reported the migration of Pb from black polythene bag into banana. They reported that Pb which is a residue from the polymerization process of polythene can migrate at high temperatures. Since chemical ripening agents like carbide are used to generate heat, the high temperature needed for the heavy metals to migrate is provided (Sogo-Temi *et al.*, 2014). Chromium was also detected in all the groups, with the highest amount occurring in the group fed carbide ripened banana. Chromium toxicity is related to Chromium (VI), due to its high absorption, easy penetration of the cell membranes, and its genotoxicity and oxidizing properties. Groups 1, 2, 3, and 4 fell within the recommended intake of chromium except for group 5 which had a higher Chromium value. Arsenic values for groups 4 and 5 were increased when compared to groups 1, 2, and 3. The highest level of As was seen in group 5. This may be as a result of the high level of calcium carbide used in ripening the fruit to achieve quick ripening; this is in agreement with Igbinaduwa et al. (2018). Arsenic is one of the most toxic metals in the natural environment, chronic arsenic ingestion leads to accumulation of arsenic in the liver, kidneys, heart, and lungs, with smaller amounts in the muscles, nervous system, gastrointestinal tract, and spleen (Hakim *et al.*, 2012). This result is in agreement with Sobukola *et al.*, (2010) and Sogo-Temi *et al.*, (2014) who also found high levels of Pb, As and Cr in some fruits and leafy vegetables from selected markets in Nigeria.

Bio-accumulation of heavy metals in the body poses a serious health risk to the consumers of artificially ripened fruits especially those with high consumption rates (Samuel *et al.*, 2018). The use of Estimated Daily Intake (EDI) helps in the identification of the tolerable level of heavy metal ingestion. Therefore, estimated daily intake or 'tolerable intake' is widely used to describe 'safe' levels of intake of heavy metals. From the results shown in (Table 4), the EDI values of Lead (Pb) for both children and adults were above the tolerable daily intake except for the control group (Group 1) which fell within the acceptable limit. Chromium (Cr) EDI was found to be below the TDI of 0.15mg/kgbwt/day for both children and adults for all the groups. Also, Arsenic for all groups fell within the established limits except for group 5 which was above the TDI value. From the EDI values of all the heavy metals, it is evident that the EDI for both adults and children is within the same value. Children who consume bananas exposed to calcium carbide stand a chance of having higher quantities of heavy metals and, given that their rate of metabolism is much less than adults, they stand a higher risk of being affected by the adverse effect being caused by heavy metals, as such children should be prevented from regular consumption of carbide ripened bananas. This study is in agreement with other studies on the potential health risk of heavy metals to residents at long-term consumption of contaminated foods (Mahfuza *et al.*, 2017; Onuoha *et al.*, 2016; Orisakwe *et al.*, 2012; Orisakwe and Ajaezi, 2014).

Toxic Hazard Quotient (THQ) studies through the consumption of bananas treated with different ripening agents is a measure of the chemical contaminants in the fruit; it is a dimensionless index of risk associated with long term exposure to chemicals. THQ is not a measure of risk but indicates a level of concern. THQ values can either be < 1 or > 1.When THQ > 1, it indicates a reason for public health concern. From the results established, the THQ of Pb for group 1 (children) and groups 1, 2, and 3 (adults) were less than one (< 1) indicating no reason for a public health concern, while groups 1, 2, 3, and 4 (children) and groups 4 and 5 (adults) were significantly greater than one (> 1), giving reasons for public health concern. The THQ of Cr (as shown in 4) for both adults and children were significantly less than 1, this indicates that people who consume artificially ripened bananas at that particular dosage are not exposed to the health risk of chromium. Also, THQ values for As for groups 1, 2, 3, and 4 (children and adults) were < 1 indicating that consumers are not exposed to the health risk of arsenic, while group 5 (children and adults) was > 1 indicating a reason for public health concern. From the THQ values obtained, it is evident that Pb especially for children have incredible high values, these make it a reason for serious public health concern because the hazard potential that could be caused by this high toxicity may be deleterious to human health. Also, the difference in THQ values for adults and children can be attributed to the difference in body weight (Reham *et al.*, 2013). According to Onuoha *et al.*, (2016) and Patrick-Iwuanyanwu and Chioma (2017), significantly higher THQ value has a relatively higher potential health risk to human beings who are the consumers.

Carcinogenic Risk (CR) is expressed as the probability of contracting cancer over a lifetime of 70 years as a result of continuous consumption of carbide ripened banana over one's entire lifetime (Onuoha *et al.*, 2016). Pb, Cr, and As are classified by the IARC as being carcinogenic agents (Mahfuza *et al.*, 2017). Chronic exposure to low doses of Pb, Cr, and As could therefore result in many types of cancers. In general, USEPA considers excess cancer risks that are below about 1 chance in 1,000,000 (1×10^{-6} or 1E-06) to be so small as to be negligible, and risks above 1 in 10,000 (1×10^{-4} or 1E-04) to be sufficiently large that some sort of remediation is required. The benchmark for gathering additional information is an incremental lifetime carcinogenic risk (ILCR) greater than one in ten thousand ($> 10^{-4}$) whereas 1 in 1000 or greater (ILCR $> 10^{-3}$) is moderately increased risk and should be given high priority as a public health concern (Bamuwamye *et al.*, 2015). According to the results of (Table 6), carcinogenic risk values for Pb in groups 1, 2, 3, 4 and 5 are 2.1E-5, 4.3E-5, 4.3E-5, 6.4E-5 and 9.2E-5 respectively, showing probable cancer cases of 21 in 100,000 people, 43 in 100,000 people, 43 in 100,000, 64 in 100,000 and 92 in 100,000 people respectively. This indicates that the values obtained for Pb probable cases are below the USEPA standard (ILCR < 1E-6) and as such is as small as to somewhat negligible. Carcinogenic risk values of Cr for groups 1, 2, 3, 4, and 5 were 2.5E-4, 3E-4, 3E-4, 6E-4, 8E-4., indicating cancer cases of 25 in 10,000 people, 3 in 10,000 people, 3 in 10,000 people, 6 in 10,000 people, and 8 in 10,000 people respectively. The values were also below the USEPA standard (ILCR < 1E-6) and, as such, are not indicative of high chances of cancer. The result for As for groups 1, 2, 3, 4, and 5 were 9E-4, 1.4E-3, 1.2E-3, 1.7E-3 and 1.8E-2. These values indicate that consumption of artificially ripened bananas will result in 14 cancer cases per 1000 people, 12 cancer cases per 1000 people, 17 cancer cases per 1000 people, and 18 cancer cases per 100 people for groups 2, 3, 4, and 5 respectively, as opposed to 9 cancer cases per 10,000 people for group 1, Arsenic values exceed USEPA standards (ILCR > 10-3). It is indicative of a highly increased chance of contracting cancer over one life's time and should be given high priority as a public health concern.

Conclusion

Calcium carbide used in this study was seen to contain traces of potential toxic elements. Consumption of carbide ripened bananas is of great public health concern because accumulation of potential toxic elements in the body affects different biological process. Therefore, the use of calcium carbide as a ripening agent should be discouraged.

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Declarations

Conflict of interest

None

Authors' contributions

Author UCS (though now of Blessed Memory) conceived the idea and supervised the work. Author NJU carried out the experiment and drafted the work. Author OCA co-supervised and proofread the manuscript. All authors agreed to the final manuscript.

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