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Comparative Assessment of the Phytochemical and Selected Heavy Metal Levels in *Cucumis sativus* L. and *Solanum aethiopicum* L. Fruit Samples Grown in South Eastern and North Central Regions of Nigeria Respectively

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Abstract

Studies were carried out to comparatively assess the phytochemical and heavy metal levels in *Solanum aethiopicum* L. and *Cucumis sativus* L. fruit samples grown in the South Eastern and North Central regions of Nigeria respectively using standard analytical procedures and instrumentation. The fruit samples were assayed for selected heavy metals (Pb, Cd and Cu) using atomic absorption spectrophotometer after wet digestion of the samples. The five detected phytochemicals (flavonoids, alkaloids, terpenoids, saponins and glycosides) were present at varying amounts in the investigated fruit samples from the South Eastern and North Central regions of Nigeria. The range of mean values of flavonoids, terpenoids, saponins and glycosides in the *S. aethiopicum* L. fruit samples from the two studied regions were 0.50 - 0.57, 0.53 - 1.26, 0.44 - 0.78, 1.12 - 1.93 and 0.40 - 0.50 mg/g respectively. The range of mean values of flavonoids, alkaloids, terpenoids, saponins and glycosides in the *C. sativus* L. fruit samples from the two studied regions of Nigeria were 1.27 - 1.69, 0.53 - 0.55, 0.96 - 1.51, 0.41 - 0.83 and 0.90 - 1.74 mg/g respectively. The range of mean vales of Pb, Cd, and Cu in the *S. aethiopicum* L. fruit samples from the two studied regions were 0.15 - 0.24, 0 - 0.01, 0.78 - 1.12 µg/g respectively. 0.31 - 0.40, 0.02 - 0.05 and 0.62 - 0.96 µg/g were the range of mean values of Pb, Cd and Cu respectively in the *C. sativus* L. fruit samples from the two studied regions of Nigeria. Of the three investigated heavy metals,

only Cd was at toxic levels in the *C. sativus* L. fruit samples from the South Eastern and North Central regions of Nigeria. This is therefore a health concern to the fruit consumers that includes these fruits in their habitual daily fruit diets. Although the therapeutic and pharmaceutical benefits that would be derived from consuming, the investigated fruit samples has been shown in this study, there is therefore a possible risk of undue exposure to environmental pollutants such as heavy metal, especially through growing these fruits in polluted soils resulting from unwholesome anthropogenic practices. For fruit consumers to derive maximum health benefits from consuming these fruits, pollutants like heavy metals must be at non-toxic levels and this can only be achieved by ensuring that these fruits samples are grown and harvested in environments with less anthropogenic activities.

Keywords

Cucumis *sativus* L., *Solanum aethiopicum* L., Phytochemicals and Heavy Metals, North Central Region and South Eastern Region

1. Introduction

Throughout the world from ancient times, fruits and vegetables have always formed an important part of diet for both human and animals [1]. Fruits and in general plants are sources of food to meet nutritional needs as well as some medicinal and therapeutic purposes.

Fruits and vegetables are consumed fresh or in processed form and known to be among the most important sources of phytochemicals for the human diet [2]. About 200,000 phytochemicals are known so far with about 20,000 of them have been identified as originating from fruits, vegetables and grains [3].

Phytochemicals have been identified as having antioxidant, antibacterial, antifungal, anti-viral, cholesterol-lowering, anti-thrombotic and anti-inflammatory properties [2].

According to [4], phytochemicals are some of the most important natural preservation structures that help to reduce and inhibit pathogenic macro-organisms growth and preserve the overall quality of food products.

[5] stated that dietary intake of phytochemicals may promote health benefits, protecting against chronic degenerative disorders, such as cancer, cardiovascular, neuro-degenerative diseases, diabetes, high blood pressure, inflamation, ulcers, osteoporosis, parasitic viral and microbial infections epidemiological and animal studies suggest that the regular consumption of fruits vegetables and whole grains reduces the risk of chronic diseases associated with oxidative damage [6].

Cucumis sativus L. is a widely cultivated plant of the gourd family which is eaten in the unripe, green form [7].

Its fruit extract has shown free radical scavenging and analgesic properties in

mice as reported by [8].

Studies by [9] have shown the anti-oxidant and anti-ulcer effects of *C. sativus* L. extracts in rats.

According to [7], *C. sativus* L. fruit contains several phytochemicals possessing antioxidant activity and the major groups of phytochemicals include vitamins A, C, E and K, carotenoids, tarpenoids, flavonoids, polyphenols, saponins, enzymes and minerals.

Solanum aethiopicum L. fruits can be eaten raw and also when boiled or fried, used as ingredient of stews, soups and vegetable sauces [10]. Wide variations exist within the vegetable and fruit characters both within and between the African egg species including variations of characters like diameter of corolla, petile length, leaf blade width, plant branching, fruit shape and colour [11]. The uses of *S. aethiopicum* L. fruits in indigenous medicine range from weight reduction to treatment of several ailments including asthma, allergic rhinitis, nasal catarrh, skin infections, rheumatic disease, swollen joint pains, gastro-esophageal reflux disease, constipation and dyspepsia [12].

The therapeutic and pharmacological importance of *S. aethiopicum* L. has been attributed to the presence of certain chemical substances such as phenols, anthocyanin, glycol alkaloids, flavonoids, saponins, ascorbic acid and a-chronine etc. [13].

Although heavy metals are naturally occurring elements, found throughout the earth's crust, most environmental contamination and human exposure arise from human activities such as mining and smelting operations, industrial production, domestic and agricultural activities [14].

Heavy metals are natural constituents of the environment, usually occurring in low concentration under normal conditions. Heavy metals contamination of vegetables and fruits cannot be underestimated as these food stuffs are important components of human diet [15].

Heavy metals can be readily taken up by vegetable and fruit roots and can be accumulated at high levels in the edible parts of plants. Anthropogenic activities can cause elevated levels of heavy metals in various parts of the ecosystem and may occur through various diffused and point sources [16].

According to [17] assessment of heavy metal compositions of vegetables and fruits is one of the most important methods used for monitoring environmental pollution as elevated levels of the elements in the human body is known to cause a number of serious metabolic and toxic discase disorders and effects.

Since fruits such as *C. sativus* L. and *S. aethiopicum* L. are known to be rich in secondary metabolites or phytochemicals that bring therapeutic effects to the body at regular consumption, geographical location of these fruits and the anthropogenic activities going on in such environment directly or indirectly plays a key role in determining the levels of phytochemicals as well as environmental pollutants such as heavy metals in these fruits.

Therefore, studies were carried out to assess the levels of phytochemicals and heavy metals in *C. sativus* L. and *S. aethiopicum* L. fruit samples grown in South

Eastern and North Central regions of Nigeria respectively.

2. Sample Collection and Identification

The fruit samples of *Cucumis sativus* L. and *Solanum aethiopicum* L. were purchased in major fruit market outlets in Enugu and Ebonyi states respectively in the South Eastern region of Nigeria while for the North Central region, the fruit samples were purchased at market outlets in Benue and Plateau states respectively. The fruit samples were identified in the department of Applied Biology, Enugu State University of Science and Technology, Enugu State. The healthy fruit samples were selected and thoroughly washed with water to remove dirt's and unwanted particles.

2.1. Preparation of Samples

Fruit samples of *C. sativus* L. *and S. aethoiopicum* L. from the differently studied environments were sliced into shreds and oven dried at 150˚C and then pulverized to obtain a fine dry powder.

The pulverized fruit samples were stored in air-tight containers at room temperature prior to analysis.

2.2. Quantitative and Qualitative Phytochemical Analysis of the Samples

Aqueous extract of the pulverized fruit samples of *C. sativus* L. *and S. aethoiopicum* L. were prepared by dissolving 20 g each of the samples with 70% ethanol in a 500 ml conical flask. The extracting mixture was allowed to stand for 24 hours and was subsequently filtered using Whatman filter paper No. 42 (125 mm).

The filtrate was afterwards concentrated in an oven at 80˚C [18]. The extracts of *C. sativus* L. *and S. aethoiopicum* L. fruit samples were tested for flavonoids, alkaloids, terpenoids, saponins and glycosides as described by [19].

Quantitative determination of glycosides and terpenoids were done using alkaline picrate method and oxidation method respectively as described by [19].

Saponin content was quantitatively estimated by spectrophotometric method of [20].

The flavonoid content was estimated using ferric chloride colorimetric methods of [21].

Quantitative determination of alkaloid content was carried out by oxidation method as described by [19].

2.3. Digestion and Determination of Heavy Metals

2 g of each of the samples were weighed into Kjedahls flask mixed with 20 ml of concentrated sulphuric acid, perchloric acid and nitric acid in the ratio of 1:4:40 and left to stand overnight.

There after the flask was heated at 70˚C for about 40 min and then increased to 120˚C. The digestion was completed after the solution became clear and white

fumes appeared. The digest was diluted with 20 ml of distilled water and boiled for 15 min. The solution was cooled and transferred into 100 ml volumetric flasks and diluted to the mark with distilled water. The sample solution was then filtered with a Whatman filter paper No. 42 (125 m) into screw capped polyethylene bottles and the procedure was repeated for all the samples. The levels of Pb, Cd, and Cu in the *C. sativus* L. *and S. aethiopicum* L. fruit samples from the South Eastern and North Central regions of Nigeria respectively were determined using atomic absorption spectrophotometer (AAS) *PG*, 550 Model as described by [22].

2.4. Statistical Analysis

The data obtained was expressed as mean ± standard deviation and subjected to one way analysis of variance (ANOVA) at 5% level of confidence using SPSS version 22.0.

3. Results and Discussion

3.1. Flavonoids

Result of Table 1 shows that the ethanolic extracts of *S. aethoiopicum* L. fruit samples from the South Eastern and North Central regions of Nigeria had trace presence of flavonoids with mean values of 0.57 ± 0.08 and 0.50 ± 0.00 mg/g respectively. The levels of flavonoids in the extracts of *S. aethiopicum* L. fruit samples from South Eastern region was slightly higher than it was in those from the North Central region of Nigeria.

Also, flavonoids were found to have high presence in the extracts of *C. sativus* L. fruit samples from the South Eastern region of Nigeria while moderate presence of the phytochemical was found in the *C. sativus* L. fruit samples from the North Central region. 1.69 ± 0.13 and 1.27 ± 0.10 mg/g were obtained as mean values of flavonoids in the *C. sativus* L. fruit samples from the South Eastern and North Central regions of Nigeria respectively as represented in Table 2.

[23] observed a moderate presence of flavonoids in the extracts of *C. sativus* L. fruit samples from Uba Hong Local Government Area of Adamawa state which

Table 1. Qualitative screening and mean values of selected phytochemicals in the *S. aethiopicum* L. fruit samples from the South Eastern and North Central regions of Nigeria.

Phytochemical	Fruit samples from the South Eastern region		Fruit samples From the North Central region	
	Qualitative screening	Quantitative value (mg/g)	Qualitative screening	Quantitative value (mg/g)
Flavonoids	+	0.57 ± 0.08	+	0.50 ± 0.06
Alkaloids	++	1.26 ± 0.10	+	0.53 ± 0.13
Terpenoids	+	0.44 ± 0.03	++	0.78 ± 0.11
Saponins	++	1.12 ± 0.07	+++	1.93 ± 0.09
Glycosides	+	0.40 ± 0.05	+	0.31 ± 0.06

Key: +++ (highly present); ++ (moderately present); + (present in trace amounts).

Table 2. Qualitative screening and mean values of selected phytochemicals in the *C. sativus* L. fruit samples from the South Eastern and North Central region of Nigeria respectively.

Phytochemical	Fruit samples from the South Eastern region		Fruit samples from the North Central region	
	Qualitative screening	Quantitative value (mg/g)	Qualitative screening	Quantitative value (mg/g)
Flavonoids	+++	1.69 ± 0.13	++	1.27 ± 0.10
Alkaloids	+	0.55 ± 0.07	+	0.53 ± 0.04
Terpenoids	++	0.96 ± 0.14	+++	1.51 ± 0.11
Saponins	++	0.83 ± 0.04	+	0.41 ± 0.03
Glycosides	+	0.90 ± 0.05	+++	1.74 ± 0.18

Key: +++ (highly present); ++ (moderately present); + (present in trace amounts).

agreed completely with the observed presence of the phytochemical in the studied *C. sativus* L. fruit samples from the North Central Region of Nigeria.

The presence of flavonoids in the studied fruit samples from the investigated regions of Nigeria shows that the fruits are of medicinal and pharmacological benefits to man.

According to [24], flavonoids plays important roles in biological activities including antiallergenic, antibacterial, antiviral and antifungal effects.

[7] went further to say that flavonoids and their microbial effects are useful as a food preservative to extend the shelf life and safety of foods.

The varied presence of flavonoids in extracts of *C. sativus* L. fruit samples grown and harvested in South Eastern and North Central regions of Nigeria respectively could be attributed to differences in geographical location and soil chemistry where the fruit samples grew.

3.2. Alkaloids

Result of Table 1 shows that alkaloids had moderate presence in the *S. aethiopicum* L. fruit samples from South Eastern region while a trace presence of the phytochemical was observed in the ethanolic extracts of the fruit samples from the North Central region of Nigeria.

1.26 ± 0.10 and 0.53 ± 0.13 mg/g were the mean values of alkaloids in the *S. aethiopicum* L. fruit samples from the South Eastern and North Central regions of Nigeria respectively.

Additionally, alkaloids were observed to be present in trace amounts in the extracts of *C. sativus* L. fruit samples from the South Eastern and North Central regions of Nigeria respectively as represented in Table 2.

The mean values of alkaloids in the *C. sativus* L. fruit samples from the South Eastern and North Central regions of Nigeria were 0.55 ± 0.07 and 0.53 ± 0.04 mg/g respectively as shown in Table 2.

[25] reported trace presence of alkaloids in *S. aethiopicum* L. fruit samples

from Isiala Ngwa North Local Government Area of Abia State, which conformed with the observed presence of alkaloids in the *S. aethiopicum* L. fruit samples from the South Eastern and North Central regions of Nigeria respectively. [1] obtained a higher mean value of 1.06 ± 0.19 mg/g for alkaloids in the *Cucumis metuliferus* fruit samples from Gboko, Benue State than what was reported in this study for *Cucumis sativus* L. fruit samples from the North Central and South Eastern regions of Nigeria respectively.

[10] stated that the bitterness of egg plants is due to the presence of alkaloids and that poisoning by *Solanum* species has been attributed to the presence of glycol-alkaloids which causes diarrhea.

According to [7], alkaloids and saponins are known to exhibit antispasmodic and antimicrobial activities, lower blood pressure, balance the nervous system and protects plants from microbial pathogens.

3.3. Terpenoids

Result of **Table 1** shows that terpenoids were observed to have trace presence in the extracts of *S. aethiopicum* L. fruit samples from the South Eastern region where as moderate presence was observed for the ethanolic extracts of the fruit samples the from North central region of Nigeria.

0.44 ± 0.03 and 0.78 ± 0.11 mg/g were the mean values of terpenoids in the *S. aethiopicum* L. fruit samples from the South Eastern and North Central regions of Nigeria respectively.

Additionally, the ethanolic extracts of *C. sativus* L. fruit samples from the South Eastern region had moderate presence of terpenoids, where as the extracts of the fruit samples from the North Central region had very high presence of terpenoids as shown in **Table 2**.

Result of **Table 2** shows that the mean values of terpenoids in the *C. sativus* L. fruit samples from the South Eastern and North Central regions of Nigeria were 0.96 ± 0.14 and 1.51 ± 0.11 mg/g respectively. [23] reported a very high presence of terpenoids in the ethanolic extracts of *C. sativus* L. fruit samples collected from Uba Hong Local Government Area of Adamawa State, which completely agreed with the observed presence of the phytochemical in the *C. sativus* L. fruit samples from the studied North Central region of Nigeria.

[5] stated that terpenes have a unique antioxidant activity in their interaction with free radicals because it reacts with free radicals by partitioning themselves into fatty acid membranes by virtue of their long carbon side chain.

The most studied terpene antioxidants are the tocotrienols and tocopherols and are effective apoptotic inducers for human breast cancer cells [7].

The impact of a diet of fruit vegetables and grains on reduction of cancer risk may be explained by the actions of terpenes *in vivo* [26].

3.4. Saponins

Result of **Table 1** shows that the ethanolic extracts of *S. aethiopicum* L. fruit

samples from the South Eastern region had moderate presence of saponins while the extracts of the fruit samples from the North Central region of Nigeria had very high presence of the phytochemical.

1.12 ± 0.07 and 1.93 ± 0.09 mg/g were obtained as mean values of saponins in the *S. aethiopicum* L. fruit samples from the South Eastern and North Central regions of Nigeria respectively as shown in Table 1.

Also, saponins were observed to have moderate presence in the extracts of *C. sativus* L. fruit samples from the South Eastern region, where as the phytochemical had trace presence in the extracts of the fruit samples from the North Central region as represented in Table 2.

0.83 ± 0.04 and 0.41 ± 0.03 mg/g were obtained as mean values of saponins in the *C. sativus* L. fruit samples from the South Eastern and North Central regions of Nigeria respectively as given in Table 2.

[27] reported a moderate presence of saponins in *C. sativus* L. fruit samples from Nsukka, Nigeria, which compared very well with the observed presence of the studied *C. sativus* L. fruit samples from the South Eastern region of Nigeria.

However, [27] reported a higher mean value of 2.01 ± 0.08 mg/g for *C. sativus* fruit samples from Nsukka, Nigeria than it was obtained for the phytochemical in the fruit samples from the two investigated regions of Nigeria.

According to [27] saponins has the property of coagulating red blood cells, anti-inflammation, allelopathy, cholesterol-lowering.

[23] stated that saponins are known to be immune boosters.

3.5. Glycosides

Result of Table 1 shows that glycosides had trace presence in the extracts of *S. aethiopicum* L. fruit samples from the South Eastern and North Central regions of Nigeria respectively.

The mean values of glycosides in the of *S. aethiopicum* L. fruit samples from South Eastern and North Central regions of Nigeria were 0.40 ± 0.05 and 0.51 ± 0.06 mg/g respectively as shown in Table 1.

Also, glycosides were observed to have moderate presence in the *C. sativus* L. fruit samples from the South Eastern region, where as the phytochemical had an observed very high presence in the fruit samples from the North Central region of Nigeria as represented in Table 2.

0.90 ± 0.8 and 1.74 ± 0.18 mg/g were the mean values gotten for glycosides in the *C. sativus* L. fruit samples from the South Eastern and North Central regions of Nigeria respectively as given in Table 2.

[27] reported a very higher mean value of 32.23 ± 0.41 mg/g for glycosides in *C. sativus* L. fruit samples from Nsukka, Nigeria, than what was obtained for the phytochemical in the *C. sativus* L. fruit samples from the two studied regions of Nigeria.

[23] reported a very high presence of glycosides in the *C. sativus* L. fruit samples from Uba Hong Local Government Area of Adamawa State, which com-

pletely agreed with the observed presence of the phytochemical in the studied *C. sativus* L. fruit samples from the North Central region of Nigeria.

[6] stated that glycoside*s* help to normalize blood pressure, balance blood sugar, lower cholesterol and blood lipids and improve liver function.

3.6. Lead

Lead is an extremely toxic heavy metal that disturbs various plants physiological processes and fastens the production of reactive oxygen species (ROS), causing lipid membrane damage that ultimately leads to the damage of chlorophyll and therefore suppresses the overall growth of the plant [17].

Result of Table 3 shows that the mean levels of Pb in *S. aethiopicum* L. fruit samples from the South Eastern and North Central regions of Nigeria, were 0.24 ± 0.02 and 0.15 ± 0.08 µg/g respectively.

The mean levels of Pb in the *S. aethiopicum* L. fruit samples were within the [28] recommended permissible limits for the metal in edible food products.

The mean levels of Pb in the *S. aethiopicum* L. fruit samples from the South Eastern Region were observed to be statistically higher than that from the North Central region of Nigeria. This could be attributed to varying intensities of anthropogenic activities going on in the environments where the fruit samples were grown and harvested.

Examples of such anthropogenic activities include nearness of farm to automobile mechanic workshop vehicular emissions, industrial discharges, fertilizer application and mining operations etc.

Result of Table 4 shows that Pb had mean levels of 0.4 ± 0.05 and 0.31 ± 0.02 (µg/g) in the *C. sativus* L. fruit samples from the South Eastern and North Central

Table 3. Mean heavy metal levels in the *S. aethiopicum* L. fruit samples grown in the South Eastern and North Central regions of Nigeria respectively.

Heavy metal (µg/g)	Samples from the South Eastern region	Samples from the North Central region	F test p value	[28] STD
Pb	0.24 ± 0.02	0.15 ± 0.08	0.02	0.5
Cd	0.01 ± 0.00	-	0.01	0.02
Cu	0.78 ± 0.10	1.12 ± 0.16	0.01	2.00

The results represent mean ± standard deviation of triplicate experiment (n = 3).

Table 4. Mean heavy metal levels in the *C. sativus* L. fruit samples from the South Eastern and North Central regions of Nigeria respectively.

Heavy metal (µg/g)	Samples from the South Eastern region	Samples from the North Central region	F test p value	[28] STD
Pb	0.40 ± 0.05	0.31 ± 0.02	0.02	0.5
Cd	0.05 ± 0.01	0.0 ± 0.00	0.01	0.02
Cu	0.62 ± 0.08	0.96 ± 0.05	0.01	2.00

The results represent mean ± standard deviation of triplicate experiment (n = 3).

regions of Nigeria respectively.

The mean levels of Pb in the fruit samples from the two studied regions were statistically significant and equally within the WHO recommended limits.

Although Pb was within permissible limits in the *C. sativus* L. fruit samples from the two studied regions, the mean values obtained showed intense contamination of the fruit samples with the metal and therefore a health concern especially on prolonged exposure to the metal through fruit diets.

[29] reported a mean value of 0.13 µg/g for Pb in *S. aethiopicum* L. fruit samples sold at Ologbo market in Benin City, Edo State, which compared very well with what this study obtained for Pb in *S. aethiopicum* L. fruit samples from North Central region of Nigeria.

[29] also stated that Pb is a harmful body poison that can enter into the human system through air, water and food and cannot be eliminated by fruits and vegetable washing.

3.7. Cadmium

Cadmium was only detected in the *S. aethiopicum* L. fruit samples from the South Eastern region of Nigeria with a mean value of 0.01 ± 0.00 mg/g as shown in **Table 3**. The mean value of Cd in the fruit samples was within the recommended permissible limits. 0.05 ± 0.01 and 0.02 ± 0.00 µg/g were the mean values obtained for Cd in *C. sativus* L. fruit samples from the South Eastern and North Central regions of Nigeria respectively as represented in **Table 4**.

The mean value of Cd in the *C. sativus* L. fruit samples from the South Eastern region was above the recommended permissible limits while the metal's mean value in the fruit samples from the North Central region was at the border line of the permissible limits. The levels of Cd in the *C. sativus* L. fruit samples from the two studied regions were statistically significant.

[29] reported a higher mean value of 0.845 ± 0.19 µg/g for Cd in *S. aethiopicum* L. fruit samples sold at Uselu market in Benin City, Edo state, than what this study obtained for the metal in the *S. aethiopicum* L. fruit samples from the South Eastern region of Nigeria.

According to [30], cadmium is a highly toxic non-essential heavy metal that is well recognized for its adverse influence on the enzymatic systems of cells, oxidative stress and for inducing nutritional deficiency in plants.

3.8. Copper

Result of **Table 3** shows that the mean values of Cu in the *S. aethiopicum* L. fruit samples from the South Eastern and North Central regions of Nigeria were 0.78 ± 0.10 and 1.12 ± 0.16 µg/g respectively.

The levels of Cd in the fruit samples from the two studies regions of Nigeria were statistically significant and equally within the recommended permissible limits in edible food materials.

0.62 ± 0.08 and 0.96 ± 0.05 µg/g were the mean values obtained for Cu in *C.*

sativus L. fruit samples from the South Eastern and North Central regions of Nigeria respectively as shown in Table 4.

The levels of Cu in the fruit samples from the two studied regions differed significantly and were equally within the recommended permissible limits.

Copper is an essential micro nutrient required in the growth of plants and animals.

Excessive levels of Cu in the body lead to abnormal retention of Cu in the liver (Wilson disease) [14]. The mean value of 0.32 ± 0.08 μg/g reported by [29] for Cu in *C. sativus* L. fruit samples sold at Ologbo market in Benin City, Edo State, was lower than what this study obtained for the metal in the investigated *C. sativus* L. fruit samples from the two studied regions of Nigeria.

4. Conclusions

Flavonoids, alkaloids, terpenoids, saponins and glycosides were all found present although at varying amounts in the investigated fruit (*Cucumis sativus* L. and *Solanum aethiopicum* L.) samples from the two studied regions of Nigeria.

C. sativus L. and *S. aethiopicum* L. fruit samples from South Eastern region were observed to have moderate to very high presence of alkaloids, saponins, glycosides and flavonoids, where as the investigated fruit samples from the North Central region of Nigeria had moderate to very high levels of saponins, terpenoids, flavonoids and glycosides.

The varying amounts of the detected phytochemicals in the investigated fruit samples from the two studied regions of Nigeria, were attributed to differences in geographical location and soil chemistry, where the fruits were grown and harvested.

The presence of the detected phytochemicals in the investigated fruit samples from the two studied regions of Nigeria shows that consumption of these fruit samples by the people especially on regular basis would be of immense therapeutic and pharmacological importance.

The mean levels of Cd, Pb and Cu in the investigated fruit samples from the two studied regions of Nigeria were statistically significant.

Cd was at toxic levels in the *C. sativus* L. fruit samples from the two studied regions of Nigeria.

Taken into consideration the fact that Cd is a non-essential element and equally very toxic at very low concentrations, its levels in edible fruits, vegetables and food are of immense interest to scientists and environmentalists. It is important that fruits which usually form diets to people of all ages, are grown and harvested in environments with less anthropogenic activities and practices by the people that introduce excess pollutants into the soil should be checkmated by relevant authorities so as to prevent undue exposure to heavy metals through fruits consumption.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

[1] Achikanu, C.E., Ani, O.N. and Onyishi, C.K. (2020) Proximate, Phytochemical and Vitamins Compositions of *Cucumis metuliferus* (Horned Melon) Rind. *Journal of Complemantary and Alternative Medical Research*, **9**, 40-50. https://doi.org/10.9734/jocamr/2020/v9i330144

[2] Schreiner, M. and Huyskens-Keil, S. (2006) Phytochemicals in Fruits and Vegetables. *Critical Review of Plant Science*, **25**, 267-278. https://doi.org/10.1080/07352680600671661

[3] Patra, A.K. (2012) Phytochemicals and Microbes. Springer, Dordrecht, 266-269. https://doi.org/10.1007/978-94-007-3926-0

[4] Taj Karimi, M. and Ibrahim, S.A. (2012) Phytochemicals as Antimicrobial Food Preservatives. In: Patra, A., Ed., *Dietary Phytochemicals and Microbes*, Springer, Dordrecht, 207-235. https://doi.org/10.1007/978-94-007-3926-0_7

[5] Prakash, D., Gupta, C. and Sharma, G. (2002) Importance of Phytochemicals in Nutraceuticals. *Journal of Chinese Medicine Research and Development*, **1**, 70-78.

[6] Cieslik, E., Greda, A. and Adamus, W. (2006) Contents of Polyphenols in Fruits and Vegetables. *Food Chemistry*, **94**, 135-142. https://doi.org/10.1016/j.foodchem.2004.11.015

[7] Mandev, J.S., Wolayan, F.R., Pontoh, C.J. and Sondakh, B.F.J. (2019) Phytochemical Characterization of Cucumber Seeds as Candidate of Water Additive for Organic Broiler Chickens. *Journal of Advanced Agricultural Technologies*, **6**, 61-64. https://doi.org/10.18178/joaat.6.1.61-64

[8] Kumar, D., Kumar, S., Singh, J. and Singh, N. (2010) Free Radical Scavenging and Analgesic Activities of *Cucumis sativus L.* Fruit Extract in Rats. *Journal of Young Pharmacist*, **2**, 365-368. https://doi.org/10.4103/0975-1483.71627

[9] Gill, N.S., Garg, M., Bansal, R., Sood, S., Muthuraman, A. and Sharma, P.D. (2009) Evaluation of Antioxidant and Antiulcer Potential of *Cucumis Sativus L.* Seed Extract in Rats. *Asian Journal of clinical Nutrition*, **1**, 131-138. https://doi.org/10.3923/ajcn.2009.131.138

[10] Nwodo, S.C., Abayomi, C.O., Okwchukwu, K.E., Opeyemi, O.E., Olajumoke, K.A. and Damilola I.D. (2011) Proximate and Phytochemical Analysis of *Solanum aethiopicum L.* and *Solanum macrocarpon L.* Fruits. *Research Journal of Chemical Sciences*, **1**, 63-71.

[11] Osei, M.K., Banfull, B., Osei, C.K. and Oluoch, M.O. (2010) Characterization of Africa Egg Plant for Morphological Characteristics. *Journal of Agricultural Science and Technlogy*, **9**, 133-137.

[12] Bello, S.O., Muhammad, B.U., Gammaniel, K.S., Abdu-Agwye, I., Ahmed, H., Njoku, C.H., Pindiga, U.A. and Salka, A.M. (2015) Preliminary Evaluation of the Toxic-

ity and Some Pharmacological Properties of the Aqueous Crude Extract of *Solanum melongena*. *Research Journal of Agriculture and Biological Sciences*, **14**, 103-119.

[13] Noda, Y., Kneyuki, T., Igarashi, K. and Packer, M.L. (2010) Antioxidant Activity of Nasunin, an Anthocyanim in Eggplant Peels. *Toxicology*, **148**, 1123-1131. https://doi.org/10.1016/S0300-483X(00)00202-X

[14] Jamali, M.K., Kazi, T.G., Arin, M.B., Afridi, H.I., Jalbani, N. and Memom, A.R. (2007) Heavy Metal Contents of Vegetables Grown in Soil Irrigated with a Mixture of Waste Water, Sewage and Sewage Sludge in Pakistan, Using Ultra Sonic Assisted Pseudo-Digestion. *Journal of Agronomy and Crop Science*, **193**, 218-228. https://doi.org/10.1111/j.1439-037X.2007.00261.x

[15] Abdulmojeed, O.L. and Abdulrahman, A.A. (2011) Analysis of Heavy Metals Found in Vegetables from Some Cultivated Irrigated Gardens in the Kano Metropolis, Nigeria. *Journal of Environmental Chemistry and Ecotocology*, **3**, 142-148.

[16] Gwana, A.M., Bassey, E., Haruwa, L.B., Halima, B., Mustapha, U.M., Ali, M. and Laku, D. (2017) Appraisal of Some Selected Heavy Metals and Elements in Irrigated Vegetables and Fruit Cultivated in College Farm in Maiduguri, Nigeria. *International Journal of Applied Agricultural Sciences*, **3**, 78-86. https://doi.org/10.11648/j.ijaas.20170303.14

[17] Agrawal, B. (2011) Effects of Heavy Metals Contaminated Vegetables. *Indian Journal of Pharmacology*, **5**, 4-6.

[18] Okwu, D.E. (2005) Evaluation of Phyto Nutrients, Mineral and Vitamin Contents of Some Varieties of Yam (*Discorea* Spp). *International Journal of Molecular Medicine and Advances in Sciences*, **22**, 199-203.

[19] Harborne, J.B. (1998) Phytochemical Methods: A Guide to Modern Technology of Plant Analysis. 3rd Edition, Chapman and Hall, New York, 88-185.

[20] Uematsu, Y., Hirata, K. and Saito, K. (2000) Spectrophotomeric Determination of Saponin in Yucca Extract Used as Food Additive. *Journal of AOAC International*, **83**, 1451-1454. https://doi.org/10.1093/jaoac/83.6.1451

[21] Matilla, P. and Kumpulairen, J. (2002) Determination of Free and Total Phenolic Acids in Plants Derived from Foods by HPLC with Diode Array Detection. *Journal of Agricultural and Food Chemistry*, **50**, 3660-3667. https://doi.org/10.1021/jf020028p

[22] Association of Official Analytical Chemists (2003) Official Methods of Analysis. 20th Edition, Association of Official Analytical Chemists, Washington DC.

[23] Ezekiel, T.W., Sani, M. and Nachanaa, T. (2020) Comparative Study on the Phytochemical and Mineral Composition of *Cucumis sativus L.* and *Cucumis angur*ia L. (Cucumbers) from Uba. *International Journal of Innovative Science*, *Engineering and Technology*, **7**, 27-35.

[24] Tlili, N., Mejri, H., Yahia, Y., Saadaouti, E., Rejeb, S. and Nasri, N. (2014) Phytochemicals and Antioxidant Activities of *Rhus tripartitum* (Ucria) Fruits Depending on Locality and Different Stages of Maturity. *Food Chemistry*, **160**, 98-103. https://doi.org/10.1016/j.foodchem.2014.03.030

[25] Eze, S.O. and Kanu, C.Q. (2014) Phytochemical and Nutritive Composition Analysis of *Solanum aethiopicum L. Journal of Pharmaceutical and Scientific Innovation*, **3**, 358-362. https://doi.org/10.7897/2277-4572.034172

[26] Prakash, D. and Kumar, N. (2011) Cost Effective Natural Antioxidants. In: Wtson, R.R., Gerald, J.K. and Preedy, V.R., Eds., *Nutrients*, *Dietary Supplements and Nutriceuticals*, Humana Press, New York, 163-188. https://doi.org/10.1007/978-1-60761-308-4_12

[27] Agatemor, U.M., Nwodo, O.F. and Anosika, C.A. (2018) Phytochemical and Proximate Composition of Cucumber (*Cucumis sativus L.*) Fruit from Nsukka, Nigeria. *African Journal of Bio Technology*, **17**, 1215-1219. https://doi.org/10.5897/AJB2018.16410

[28] World Health Organization (WHO) and Food and Agricultural Organization (FAO) (2020) Summary and Conclusion of Joint (FAO/WHO) expert Committee on Food Additives 73rd Meeting. World Health Organization, Food and Agricultural Organization, Geneva, 200-289.

[29] Oyareme, O., Akpogheneta, S.E., Iloba, B.N. and Ogidiagba, F. (2020) Occurrence and Concentration of Heavy Metals in Garden Egg, Tomatoes, Cucumber and Water Melon from Two Major Markets in Edo State. *Food and Public Health*, **10**, 63-67.

[30] Irfan, M., Hayats, S., Ahmed, A. and Alyemeni, M.N. (2013) Soil *Cadmium* Enrichment: Allocation and Plant Physiological Manifestations. *Saudi Journal of Biological Sciences*, **20**, 1-10. https://doi.org/10.1016/j.sjbs.2012.11.004