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Evaluation of Seasonal Variations of Lead Concentration and Proximate Composition of Amaranthus *hybridus* Grown and Consumed in Ilorin, Kwara State, Northern-Nigeria

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ABSTRACT: This paper evaluates the seasonal variations in Pb concentrations and proximate composition of Amaranthus vegetable (*Amaranthus hybridus*) grown and consumed in Ilorin, Kwara State, Northern-Nigeria using appropriate standard techniques in order to ascertain its suitability for consumption. The results obtained varied with the sampling locations with the mean concentration of the Pb in soil, water and plant ranged from (1.58- 82.00mg/kg) soil, (0.11-19.37mg/l) water and (0.00-5.93 mg/kg shoots; 0.67-5.33 mg/kg roots). The values for proximate content showed that moisture content ranged from (6.38-9.99 %), ash content (2.46-6.44 %), crude protein (10.59-18.60%), crude fibre (1.63-2.39%), crude fat (3.09-4.83%) and carbohydrate (64.30-75.30%). The result obtained reveal significant level of contamination of irrigation water and *Amaranthus hybridus*as most values obtained were above the permissible limits, hence, the vegetable may constitute health hazard for the consumers. The study hence suggests that growing of the edible crops around locations that are Pb polluted should be discouraged. As for the proximate content, the values obtained are indication that all the samples had lower values of protein, fibre, and carbohydrates than the WHO recommended values for suitable dietary intake, though, with a high probability of storage due to their significant low moisture content. This underscores the nutritive value as a viable option for plant base nutrients for consumption, but as option for Pb remediation.

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Keywords: Lead; *Amaranthus hybridus*; Garden soils; Irrigation water; proximate content.

In recent years, *Amaranthus hybridus* has gained prominence due to its exceptional taste, nutritional benefits, and potential as a commercially viable leafy vegetable crop. Its popularity, nutritional richness, and appealing flavor suggest it could become a favored leafy vegetable among Northern Nigerians (Asaolu and Ajibulu, 2012). The crucial role of vegetables in human nutrition cannot be overstated, as they serve as significant sources of essential minerals and vitamins, explaining their widespread consumption in Ilorin. When it comes to leafy greens, considerations of both heavy metal accumulation and nutritional content are paramount due to their metabolic processes, which can lead to the accumulation of toxic metals harmful to human health over time (Sultana *et al*., 2017).The consumption of Amaranth (*Amaranthus hybridus*) as a

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vegetable in Ilorin, Northern Nigeria is particularly noteworthy due to its availability throughout the year regardless of season, and its affordability, catering well to the predominantly subsistence farming community in Ilorin. The assessment of heavy metal concentration, distribution, and nutritional composition in leafy vegetables is increasingly concerning for consumers, growers, agronomists, nutritionists, and toxicologists worldwide. Detoxifying lead (Pb) in food poses a significant challenge, given the frequent exposure of the population to Pb through their diets. Pb and other heavy metals can heighten oxidative activity, potentially damaging tissues and triggering stress responses Ali *et al.*, (2019). Moreover, their presence can disrupt critical cations such as potassium (K) and calcium (Ca), impacting enzyme function regulated by these ions. Analyzing the metal content of any food crop is crucial due to the hazardous and cumulative effects heavy metals can have on human health (Arora *et al*., 2008).Previous studies have highlighted the risk of significant heavy metal accumulation in edible parts of well-established Nigerian vegetables like jute mallow (Corchorus spp.), okra, and tomatoes (Türkdoğan *et al.*, 2003). Recent research in Benin City, Nigeria, found high levels of Pb and Cd contamination in undisclosed lettuce samples (Egharevba *et al.*, 2017). While research specifically on Amaranthus spp. in Nigeria (or Africa) remains limited, related studies suggest these vegetables, along with Celosia spp., have the potential to accumulate heavy metals and could serve as indicators for phytoremediation efforts (Haller and Jonsson, 2020). Therefore, the objective of this paper is to evaluate the seasonal variations in Pb concentrations and proximate composition of Amaranthus vegetable *(Amaranthus hybridus*) grown and consumed in Ilorin, Kwara State, Northern-Nigeria**.**

MATERIALS AND METHODS

Study Area: The study areas were twelve vegetable gardens in the Ilorin metropolis as sampling areas and the Botanical garden of University of Ilorin as the control site for the collection of soil and water samples to raise the vegetable. The Botanical Garden was considered as the control site because it has likely minimal level of pollution indices (Ben-Uwabor *et al*., 2020).

Study Design: The study design was conducted in both the dry and raining season in Screen house of University of Ilorin Botanical Garden, Ilorin, Kwara State, Nigeria. The area was located within latitudes $8^{0}27.812^{i}$ N and $8^{0}28.231^{i}$ N and longitudes $4^{0}38.925^{i}$ E and $4^{0}39.975^{i}$ E. The sites are characterized by rainy season, which is from April to October with a dry spell in late June and moderate rainfall in August. It has a temperature range for the wet months between 24^{0}C and 27^{0} C and, for dry months it ranges 29^{0}C and 35^{0}C

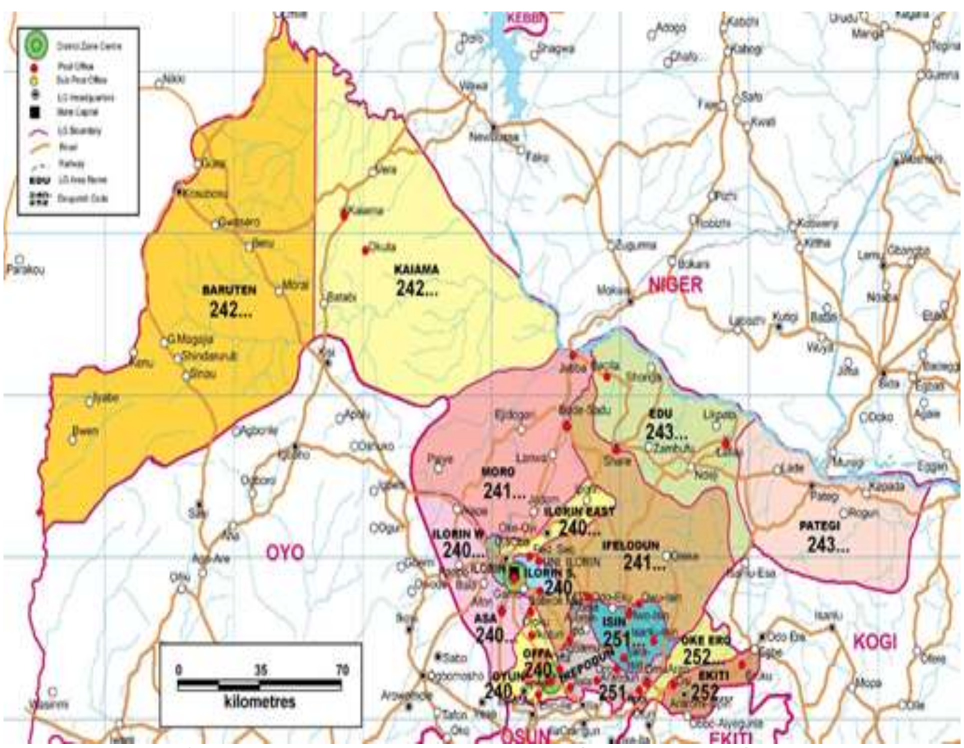

Fig 1: Map of Kwara State showing the Sampling Sites (Médecins Sans Frontières (MSF), 2021

Lead (Pb) concentration in soil from selected vegetable farms: Experimental set-up was established according to the technique outlined by Hu *et al*. (2018). The experiments were conducted in a screened house in the Botanical Garden of the University of Ilorin, Kwara State, Nigeria, with 39 well labeled polythene pots each containing 10kg of loam soils from twelve vegetable farms (locations) and the control site (University Botanical garden). The screened house was to prevent any interference. One gram representative sample from each site was also collected in a well labeled zipped bag and taken to the laboratory for heavy metal (Pb) analysis (Hu *et al*., 2018). 30 litres of water was fetched from each irrigation water source of each vegetable site and taken to the Botanical Garden for wetting the planted Amaranthus. About 1 ml of 10% HNO_3 was added to the irrigation water to stabilize the Pb concentration so that it does not form complex with the water molecule. Another 1 ml representative sample from each water source of irrigation was also taken to the laboratory to determine the concentration of Pb (Ben-Uwabor *et al*., 2021).

Lead (Pb) analysis in soil sample by wet digestion and spectrophotometer: The method of Abdulkareem *et al*. (2012) was adopted and the digestion of each soil was carried out with aqua regia solution (3 HCl: 1 HNO_3) on a hot plate for 2 hrs. After which the Pb content was determined using Perkin Elmer A Analyst 200 instrument with air acetylene flame under optimal conditions.

Quality control was assured by running the procedure in triplicate to check error and the use of blanks to check for background contamination by the reagents used. A certified reference material (IAEA-SL-1-lake sediment) was digested along with the samples and the recovery percentage of the CRM was between 72%-97%. International Atomic Energy Agency, Vienna, Austria) with Certified value of Pb as 30

Lead (Pb) analysis in Water Sample by wet digestion and spectrophotometer: Each water sample was subjected to wet digestion by the adopted method of Ogunkunle*et al*. (2015) and the Pb content was determined using PerkinElmer A. Analyst 200 Spectrophotometer.

Lead (Pb) analysis of grown vegetable samples by wet digestion and spectrophotometer: The method of Olawepo *et al*. (2020) was adopted. The Pb content was determined by Atomic Absorption Spectrometry using A. Analyst 200 Perkin Erlymer. Certified Reference Material IAEA 359 (cabbage) was digested and percentage recoveries for Pb was calculated to validate the procedure.

Determination of Proximate Composition: The nutritional content which is also referred to as the proximate analyses containing Moisture, ash, fiber, crude fats, proteins and carbohydrates of each blended vegetable sample was determined by the recommended methods of the Association of Official Analytical Chemists. All the proximate values were reported in percentage (A. O. A. C., 2019).

Statistical Analysis: All statistical analyses were performed using the Statistical Package for the Social Sciences version 20 (SPSS 20). Analysis of variance (ANOVA) was used for evaluating the significant difference between Pb concentrations in vegetables cultivated on the pots in dry and rainy seasons.

RESULTS AND DISCUSSION

Physicochemical, Lead (Pb) Concentrations of Soils, Water and Amaranthushybridus in Dry Season: Table 1 shows that the soil pH in the dry season ranged from 6.62 ± 0.04^{h} to 7.18 ± 0.03^{a} with the lowest obtained in the soil of Budo-Egba and the highest in the Mubo garden soil. The control soil recorded lower value than all the soils except Budo-Egba. All are within the pH stipulated for agricultural soil (Table 1).The values agrees with the values of Sangita (2020) in India. Moisture contents of soils in the dry season (10.13% and 18.95%) were lower than acceptable range for agricultural purpose of US EPA. (2016), (21-40%). All values for Cation Exchangeable Capacity of the gardens soils were lower (3.59-8.63 Cmolckg-^{1}) than the recommended values for agricultural soils (10Cmolckg-1). The Pb concentration of the garden soils was from 1.58 and 11.67 mg/kg, with the control soil recording lower value (2.25mg/kg) than all other soil except the soil of Odoore. The result indicated no Pb pollution in the garden soils as all have lower values than the stipulated Pb in contaminated soil (15-40mg/kg) for agricultural purposes by the US EPA. (2016). The Pb concentration of the irrigation water sources ranged from 0.03-1.52mg/l with most irrigation sources of the garden soils, including the control source recording alarming elevated concentrations of Pb than the recommended value for irrigation water source (0.038– 0.1086 mg/l). This indicated that all the irrigation water sources were polluted of Pb as at the time of study, and therefore, the irrigation water sources might be possible routes for Pb contamination of the grown *Amaranthus hybridus*. The Pb concentration of the shoot of the *Amaranthusspecie* in the dry season was between 0.00mg/kg and 0.40mg/kg, with the lowest recorded in the species of the control and the highest in Coca-Cola, Isale-Aluko and Ojagboro. The values obtained are all within the permissible level of 0.3mg/kg stipulated by US EPA. (2016), except for the species of Ojagboro, Coca-Cola and Isale-Aluko that recorded higher concentration than the permissible limit (0.3mg/kg). This indicated more Pb bound activities in those areas. This however, is an indication that the *Amaranthus hybridus* in the sampled areas with magnified values of Pb could be considered toxic. This result compares well with 0.36mg/k reported by Adefemi *et al*. (2012) in Bauchi, Northern Nigeria. The roots of the specie showed elevated Pb concentration range of 0.67-3.20 mg/kg with the lowest in the root of Amaranthus spp grown on Oyun garden soil. This range is higher than 0.3mg/kg as safe limit for vegetables. This can cause Pb health risk in human health via food chain or by consuming herbivore that feeds on the contaminated Amaranthus roots. The result pointed to the species as a very good hyperexcluder of Pb and good specie for Pb phytoremediation

The soil pH ranged from 6.70±0.17^{ab} to 6.97±0.19^{a} indicating lower soil pH range in the rainy season than the dry season, but fell within the permissible limit for soil pH for agricultural purpose. Seasonal variation was observed in the soil pH content between sites. Higher soil moisture content in the rainy season than the dry season, but lower than the permissible range for agricultural soil was recorded with the range of 15.36±0.04^{hi} and 22.72±0.02^{a}. CEC of soil in the rainy season ranged from 7.72Cmolckg-1to 8.52Cmolckg-1 with the range falling between the acceptable limit of <10 Cmolckg-1 of US EPA. (2016) for agricultural soil. The CEC of rainy season reported significant higher range than the dry season at p< 0.05 which indicated more mobility of ions in soils in the rainy season than in the dry season. The soil Pb content in some of the gardens in the rainy season have higher value than the dry season and acceptable. This might be due to higher values of cation exchangeable capacity of soils in the rainy season than in the dry season, which enhanced phytoavailabilty of Pb than in the dry season. All the roots and shoots of the Amaranthus specie, and the irrigation water sources were alarmingly polluted of Pb. The result indicated seasonal variation in pollution of Pb with higher Pb pollution indices in the rainy season than in the dry season. This suggests that the consumers of *Amaranthus hybridus* from those areas would likely face the danger of Pb toxicity as at the time of study which agrees with that reported by Gupta *et al.* (2021a).

Proximate result: The report indicated that moisture content of the vegetable in the dry season ranged from 6.38±0.02% to 6.86±0.11% with the lowest moisture content in the species of Coca-cola and the highest in the specie of the control site. The result showed lower moisture values for all the vegetables analyzed than the recommended range of 8.53-17.32 suggesting that all the samples are relatively dry when compared to the permissible level, and can therefore be stored for a long period of time without undue microbial and biochemical spoilage. The ash content varied from 2.46-6.44 %. A significant value of 6.44% was recorded in the sample from Ojagboro while the value of 2.46% which is the lowest was recorded from the sample from Ojagboro. The results of the crude fat and oils ranged from 3.09-4.91% with no significance difference (p<0.05). All the samples showed low percentage fat and oil in the spp. This is an indication of poor source of plant fat of the samples. Low fat contents in food imply low caloric value and low source of fat-soluble vitamins (Adeyeye *et al*., 2021).

Table 1: Physicochemical Analysis of Soil, Lead Conentration of the *Amaranthushybridus*, Soil and Water in Dry Season

Sites/Specimen	pH soil	Moisture (%)	CEC (Cmolckg-1)	Shoot (mgkg-^{1})	Root (mgkg-^{1})	Soil (mgkg-^{1})	Water (mgl-^{1}) (Mgml-^{1})
Otte	6.93±0.1^{c}	14.96±0.04^{c}	6.57±0.05^{b}	0.13±0.23^{c}	1.67±1.50^{b}	3.92±0.15^{d}	1.48±2.23^{a}
Budo Egba	6.62±0.04^{a}	12.85±0.03^{f}	5.54±0.10^{f}	0.13±0.23^{c}	1.07±0.23^{c}	3.58± 0.21^{de}	1.52±0.02^{a}
Budo Abio	6.88±0.01^{d}	11.74±0.02^{h}	5.06±0.15^{i}	0.13±0.23^{c}	1.05±0.23^{cd}	10.75±1.70^{ab}	1.50±0.07^{a}
Mubo	7.18±0.03^{a}	15.57±0.02^{d}	5.83±0.08^{d}	0.13±0.23^{c}	1.07±0.23^{c}	11.67±2.12^{a}	0.05±0.09^{a}
Oyun	7.05±0.04^{b}	17.73±0.03^{c}	5.41±0.19^{g}	0.13±0.23^{c}	0.67±0.61^{d}	5.08±1.54^{bc}	0.07±0.07^{a}
Ojagbooro	6.81±0.01^{f}	18.47±0.03^{b}	5.33±0.39^{h}	0.40±0.00^{a}	1.33±0.23^{bc}	2.50±4.33^{efg}	0.03±0.03^{a}
Olaolu	6.69±0.01^{f}	18.95±0.02^{a}	4.04±0.04^{k}	0.13±0.23^{c}	1.07±0.23^{c}	5.08±4.69^{bc}	0.06±0.09^{a}
Eroomo	6.63±0.04^{fg}	10.87±0.01^{i}	5.84±0.08^{d}	0.13±0.23^{c}	1.07±0.23^{c}	5.17±1.47^{b}	0.12±0.11^{a}
Okeodo	6.85±0.01^{e}	10.45±0.03^{k}	6.40±0.02^{c}	0.13±0.23^{c}	1.07±0.23^{c}	3.42±1.64^{de}	0.13±0.14^{a}
Cocacola	7.08±0.04^{b}	10.13±0.04^{l}	5.72±0.12^{e}	0.40±0.40^{a}	3.07±0.83^{ab}	3.42±1.64^{cd}	0.12±0.15^{a}
Isale Aluko	6.94±0.01^{c}	10.38±0.02^{g}	3.59±0.09^{l}	0.40±0.00^{a}	3.20±1.39^{a}	4.12±1.76^{c}	0.11±0.04^{a}
Odoore	6.68±0.01^{f}	10.58±0.02^{j}	8.63±0.09^{a}	0.27±0.23^{b}	1.07±0.23^{c}	1.58±0.63^{g}	0.06±0.07^{a}
Botanical garden (control site)	6.67±0.01^{fg}	10.57±0.02^{j}	4.80±0.11^{j}	0.00±0.00^{d}	1.07±0.23^{c}	2.25±0.43^{fg}	0.11±0.10^{a}
Permissible limit (WHO 2014)/ US EPA. (2016).	5.5-7.5	21-40	10	0.3	0.3	15-40	0.038– 0.1086

Values with the same alphabet along the column are the same at p ≤0.05. Values represent mean ±SD

Table 2: Physicochemical Analysis of Soil, Lead Concentration of the *Amaranthushybridus*, Soil and Water in Rainy Season

Site	pH	Moisture	CEC (Cmolckg-1)	Shoot (mgkg-^{1})	Root (mgkg-^{1})	Soil (mgkg-^{1})	Water (mgl-^{1}) (Mgml-^{1})
Otte	6.91±0.16^{ab}	16.82±0.03f	8.18±0.12c	3.10 ±0.29de	4.33±0.14^{b}	19.67±4.76^{cde}	15.65±0.14^{c}
Budo Egba	6.97±0.19^{a}	16.76±0.01fg	8.20±0.02c	3.59±0.25cd	3.58±0.29^{cd}	17.17±3.75^{cde}	13.95±0.21^{cd}
Budo Abio	6.88±0.16^{ab}	17.01±0.03e	8.36±0.04bc	1.33±0.12f	0.42±0.13^{i}	14.67±9.25^{cde}	6.57±0.20^{g}
Mubo	6.77±0.23^{ab}	17.58±0.03d	8.48±0.11ab	2.67±0.14e	2.27± 0.13^{g}	62.50±60.00^{bc}	9.20±0.10^{fg}
Oyun	6.75±0.05 ^{ab}	20.13±0.03b	8.51±0.04ab	3.25±0.25d	3.67±0.13^{c}	22.50±2.50^{cde}	14.72±1.18^{d}
Oja gboro	6.70±0.17^{ab}	15.64±0.02gh	7.76±0.03d	2.67±0.14e	5.33±0.14^{a}	18.67±2.26^{cde}	15.94±0.22^{cd}
Olaolu	6.71±0.13^{ab}	18.11±0.02c	8.48±0.02ab	4.33±0.37b	3.33±0.14^{de}	82.00±60.00^{ab}	17.75±0.30^{b}
Eroomo	6.59±0.08^{b}	17.54±0.04d	8.44±0.02b	2.33±0.12ef	2.67±0.13^{f}	17.75±115.67^{a}	7.35±0.60^{g}
Okeodo	6.60±0.06^{b}	16.66±0.02fgh	8.42±0.03b	3.67±0.13c	4.42±0.29^{b}	19.67±0.29^{cde}	9.90±0.20^{f}
Coca cola	6.72±0.28a^{b}	15.51±0.04ghi	7.72±0.03d	5.92±0.28a	3.42±0.28^{cde}	24.00±0.00^{cde}	19.37±1.12^{a}
Isale Aluko	6.86±0.26^{ab}	15.36±0.04hi	7.50±0.04de	3.00±0.25de	3.02±0.14^{ef}	58.50±6.00^{bcd}	11.45±0.65^{de}
Odoore	6.92±0.15^{ab}	22.72±0.02a	8.60±0.01a	0.58±0.38g	2.67±0.13^{f}	28.33±25.06^{cde}	5.70±0.20hi
Botanical garden(Ref.site)	6.93±0.18 ^{ab}	17.91±0.01cd	8.39±0.01bc	0.33±0.14h	2.08±0.12^{h}	8.00±0.50^{cde}	5.25±0.25^{i}
Permissible limit (WHO 2014)/ US EPA. (2016).	5.5-7.5	21-40	>10	0.3	0.3	15-40	0.0386 – 0.1086

Values with the same alphabet along the column are the same at p ≤0.05. Values represent mean ±SD

The crude protein content ranged from10.57-18.63% (Table 3). This indicated that the *Amaranthushybridus* grown for Ilorin consumers could serve as fair source of protein in diets if consumed regularly as values underscores fair comparison with the recommended range of 14.60-26.33%. The crude fiber contents ranged from 1.54-2.39%. The values obtained are within recommended daily allowance for children and lactating mothers. However, the values are comparatively lower than 9.5- 12.12% when compared for some medicinal plants by Shagal *et al*. (2012), but are in line with that for water leaves and okra reported by Oche *et al.* (2019). The results compare very well with the result obtained for crude fibre in spinach in Nassarawa as reported by Amos *et al*., 2023. The carbohydrate content in this study ranged from 63.16-75.30%. The values suggest significant carbohydrate content in the samples for high consumption. The Amaranthus spp from these locations could contribute significantly to the carbohydrate content of the body. Although, the results revealed no significance difference at p<0.05 in most of the samples analyzed. The plant is not a too good source of nutrient as most analyzed parameters or components recorded lower values than the recommended values for proximate composition for quality dietary values. Table 4 shows the result of the proximate analysis (%) of *Amaranthus hybridus* in rainy season. The moisture content ranged between 9.62% and 9.99 % with the highest value obtained from the control site and the least recorded for Amaranthus spp of Cocacola. Seasonal variation in the moisture content of the species was recorded with species of the rainy season having significantly higher moisture content than the specie of the dry season.

Table 3: Proximate Composition Analysis (%) of *Amaranthus hybridus* in Dry season.

Site	Moisture	Ash	Fat and oil	crude protein	Crude fibre	Percentage carbonhydrate
Otte	6.40±0.35^{d}	5.23±0.01^{c}	3.19±0.01^{c}	11.66±0.11^{d}	1.64±0.02^{c}	69.80±0.02^{abc}
BudoEgba	6.75±0.03^{b}	5.19±0.01^{c}	3.33±0.01^{c}	10.57±7.06^{de}	1.66±0.02^{c}	64.37±0.03^{c}
BudoAbio	6.79±0.04^{b}	3.52±0.02^{e}	3.98±0.01^{bc}	16.49±0.02^{b}	2.39±0.02^{a}	75.30±0.02^{a}
Mubo	6.79±0.01^{b}	5.48±0.02^{bc}	3.85±0.02^{bc}	14.51±0.02^{c}	2.35±0.02^{a}	68.51±0.17^{bc}
Oyun	6.68±0.02^{c}	5.43±0.02^{bc}	3.88±0.03^{bc}	13.69±2.45^{c}	2.29±0.02^{ab}	65.22±0.02^{c}
Ojagboro	6.74±0.02^{b}	6.44±0.02^{a}	3.74±0.01^{bc}	10.73±2.49^{de}	2.07±0.02^{b}	63.16±0.01^{c}
Olaolu	6.64±0.01^{c}	5.22±0.01^{c}	3.80±0.02^{bc}	11.57±0.03^{d}	2.34±0.01^{a}	70.24±0.02^{b}
Eroomo	6.54±0.01^{cd}	2.46±0.02^{f}	4.83±0.02^{ab}	18.59±6.93^{ab}	2.36±0.01^{a}	70.23±0.02^{ab}
Okeodo	6.81±0.01^{a}	4.42±0.02^{d}	4.16±0.02^{b}	15.63±0.06^{bc}	1.68±0.02^{c}	67.33±0.03^{bc}
Coca-cola	6.38±0.02^{d}	5.71±0.02^{bc}	3.09±0.02^{c}	10.67±0.06^{de}	1.80±0.01^{bc}	65.22±0.02^{c}
Isale-Aluko	6.75±0.08^{b}	5.98±0.01^{b}	3.67±0.30^{bc}	11.63±0.06^{d}	2.34±0.02^{a}	65.05±0.01^{c}
Odoore	6.85±0.01^{a}	4.22±0.01^{de}	4.91±0.01^{a}	18.63±0.04^{a}	1.63±0.01^{c}	64.43±0.06^{c}
(Control site	6.86±0.11^{a}	4.23±0.02^{de}	4.22±0.02$^{b\backslash\backslash}$	16.57±0.05^{b}	1.59±0.01^{c}	64.54±0.02^{c}
WHO(1989)	8.53-17.32	5.69-24.70	1.21-30.59	14.60-26.33	10.40-21.15	4.72-56.50

Values are means ± SD. Same alphabet along the column signifies significant differences at p≤0.05

The result indicated lower moisture values of all the vegetables analyzed than the recommended range of 8.53-17.32%. The moisture content obtained for the Amaranthus spp in this study suggests that all the samples are relatively dry when compared to the permissible level but have lower shelf life than species of the dry season. The ash content varied from 3.15 to 3.40 % with the highest recorded for the Isale-Aluko specie while the value of 3.15% which is the lowest, was recorded for the sample of the control specie. The values obtained indicated varied significant values from the values of the species of the dry season, but lower than the acceptable range for ash in vegetables for healthy consumption. The ash contents of this study are significantly lower than the report of Oladele, *et al*. (2020) that reported 8.63-8.74% in spinach in Nassarawa. The crude fat and oils ranged from 4.36 to 4.62% with no significance difference ($p<0.05$). All the samples showed low percentage fat and oil as compared with the stipulated WHO (1989) of 1.21-30.59%

This is an indication of poor source of plant fat from the samples. Low fat contents in food imply low caloric value and low source of fat-soluble vitamins (Adeyeye *et al*., 2021). Seasonal variation was observed with higher values recorded in the specie of rainy season than the dry season. The crude protein content in this study ranges from 14.20-14.43% (Table 4). Higher values were recorded for crude protein in the rainy season than in the dry season with significant difference at $p<0.05$, but higher than the values in the work of Adeyeye *et al*., 2021.The crude fiber contents from the *Amaranthus hybridus* ranged from 2.10-2.38%. Values in this study in both seasons were higher than values reported in the work of Amos *et al*., 2023. The values obtained in both seasons as shown (Tables 3 and 4) are within recommended daily allowance for children and for lactating mothers. However, the values obtained are comparatively lower than 9.5- 12.12% when compared for some medicinal plants by Shagal *et al.* (2012), but are in line with that for water leaves and okra reported by Oche *et al.* (2019). The results compare very well with the result obtained for crude fibre in spinach in Nassarawa as reported by Amos *et al*., 2023. The carbohydrate content in this study ranged from 64.31-64.60%. Lower carbohydrate content in the rainy season were recorded, though, values in both seasons had higher values than the WHO (1989) recommended value (4.72-56.50) for dietary vegetable. The values suggest significant carbohydrate content in the samples for high consumption, the Amaranthus spp from these locations could contribute significantly to the carbohydrate content of the body. Although, the results revealed no significance difference at $p<0.05$ in most of the samples analyzed between sites and seasons. The Amaranthus spp in most gardens are not too good sources of nutrient, as most analyzed parameters recorded lower values than the recommended values, which could have been caused by disrupted metabolic activities of the plants due to Pb interference.

Table 4: Proximate (Nutritional) Composition Analysis (%) of *Amaranthus hybridus* in the Rainy Season

Site	Moisture content	Ash content	Fat and Oil content	Crude protein content	Crude fibre content	Carbohydrate content
Otte	9.71±0.02[c]	3.25±0.02[c]	4.43± 0.02[b]	14.28±0.02[c]	2.20±0.01[b]	64.38±0.01[c]
Budo-Egba	9.74±0.03[c]	3.29±0.01[c]	4.41± 0.01[b]	14.22±0.01[c]	2.22±0.01[b]	64.42±0.02[b]
Budo-Abio	9.78±0.02[c]	3.24±0.01[c]	4.59±0.02[a]	14.34±0.01[b]	2.17±0.02[c]	64.39±0.01[c]
Mubo	9.73±0.02[c]	3.30±0.05[b]	4.54±0.01[a]	14.25±0.01[c]	2.35±0.00[a]	64. 45±0.03[b]
Oyun	9.75±0.01[c]	3.33±0.03[b]	4.57±0.05[a]	14.26±0.01[c]	2.38±0.02[a]	64.41±0.03[b]
Ojagboro	9.64±0.01[d]	3.35±0.01[b]	4.36±0.02[c]	14.20±0.01[c]	2.35±0.01[a]	64.32±0.02[c]
Olaolu	9.67±0.02[d]	3.38±0.02[b]	4.47±0.04[b]	14.39±0.01[b]	2.35±0.02[a]	64.35±0.01[c]
Eroomo	9.89±0.01[b]	3.25±0.02[c]	4.58±0.02[a]	14.37±0.01[b]	2.10±0.01[c]	64.30±0.01[c]
Okeodo	9.77±0.02[c]	3.30±0.02[b]	4.52±0.02[a]	14.41±0.01[a]	2.22±0.02[b]	64.33±0.02[c]
Coca-cola	9.67±0.01[d]	3.36±0.02[b]	4.41±0.02[b]	14.23±0.02[c]	2.37±0.02[a]	64.47±0.03[b]
Isale-Aluko	9.65±0.01[d]	3.40±0.01[a]	4.39±0.01[c]	14.20±0.01[c]	2.34±0.01[a]	64.60±0.00[a]
Odoore	9.99±0.01[a]	3.20±0.02[c]	4.55±0.03[a]	14.40±0.01[a]	2.15±0.01[c]	64.31±0.00[c]
Control site	9.94±0.01[a]	3.15±0.02[d]	4.58±0.02[a]	14.43±0.02[a]	2.14±0.02[c]	64.31±0.02[c]
WHO(1989)	8.53-17.32	5.69-24.70	1.21-30.59	14.60-26.33	10.40-21.15	4.72-56.50

Values represent Mean± SD. Values with the same superscript along the column are statistically the same at $p \leq 0.05$.

Conclusion: The investigation of the Pb and proximate content of *Amaranthus hybridus* in soils, irrigation water sources and the grown vegetables indicated that the plant was not rich in nutrients as at the time of the study. The investigated metal (Pb) is in trace amount in some of the soils between sites, but fell above the permissible levels in the vegetables and alarmingly in the irrigation water sources. The proximate analysis revealed high probability of storage of the *Amaranthus hybridus* over a long period of time without spoilage due to their low moisture content, but with underscore nutritional values due to their significantly low proximate compositions. However, relatively fair crude protein and carbohydrate contents were recorded. The results hence suggest that the physicochemical properties of the garden soils be amended, Pb pollution via irrigation water sources may constitute a hazard for the consumers, close monitoring and periodic evaluation of the plant be carried out as a precautionary measure to ensure compliance to dietary intake and safety.

Declaration of Conflict of Interest: The authors declare no conflict of interest.

Data Availability Statement: Data are available upon request from the corresponding author.

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