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Effects of Fertilizer and Accession on the Nutrient and Antinutrient Composition of the Leaf of *Senecio biafrae*

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ABSTRACT

Despite the promising opportunities for nutrition, health, and income generation in *Senecio biafrae*, this leafy green vegetable has not been brought into the regular vegetable production systems due to it being comparably slower in growth than other veggies at the early growth stage, especially without fertilizer application. Studies on the effects of fertilizer and cultivar on its nutrients and antinutrients are scanty in the literature. The effects of *Senecio biafrae* accessions (Odo-Oro and Orin-Odo), fertilizers:100% poultry manure (PM) (5 tonnes/ha), 100% NPK 15:15:15 (100 kg/ha), 50% NPK + 50% PM (50 kg/ha NPK + 2.5 tonnes/ha PM) and control (no fertilizer applied) on the nutrients and antinutrients of its fresh leaves were analyzed using standard laboratory procedures. Fertilizer and accession notably ($P<0.05$) affected the proximate, minerals and antinutrients. Crude protein ranged from 4.10-4.41%, crude fiber 0.86-1.15% and crude fat 0.93-1.20%. Potassium was in the range 217.25-254.31 mg/100 g, magnesium 36.04-37.53 mg/100 g, calcium 197.19-273.33 mg/100 g, manganese 4.62-8.95 mg/100 g, iron 5.85-9.05 mg/100 g, zinc 0.71-0.98 mg/100 g, phosphorus 334.63-404.25 mg/100 g and sodium 20.19-21.68 mg/100 g. Phytate ranged from 1.28-1.37 mg/100 g, polyphenol 21.50-23.56 mg/100 g, oxalate 0.81-0.87 mg/100 g, and hydrogen cyanide 0.21-0.23 mg/100 g in the fresh leaves. Orin-Odo demonstrated superior nutrient quality. The fertilizers enhanced the nutrients and did not significantly increase most of the antinutrients higher than the control. This implies, fertilizer application in the production of *Senecio biafrae* may not significantly increase anti-nutrients in its leaves and should be encouraged for its production.

Keywords: *Senecio biafrae*, minerals, proximate, antinutrients, vegetable, nutrients,

Introduction

Senecio biafrae is a green leafy vegetable, indigenous to and mostly grown in southern Nigeria where its supply in the market is usually far less than the quantities needed by consumers.[1] They opined that the inability of the farmers and sellers of this vegetable to meet the demands for it is because it is not yet brought into regular production in the traditional cropping systems. *Senecio biafrae* grows naturally in the forest zone of the following African countries: Ghana, Nigeria, Uganda, Liberia, Sierra-Leon, DR Congo, and Upper Guinea.[2,3,4] It is called Ota eke (Igbo; Nigeria), worowo (Yoruba; Nigeria), Bologi (Sierra Leon), Yankonteh (Ghana), Balo dede (Ivory Coast), Gnanvule (Eastern Cote d' ivore). [3, 4]

Its tender leaves have been reported to be rich in vitamins and micronutrients, low in anti-nutrients and fat.[1] *Senecio biafrae* has been documented to have several bioactivities that include: hepatoprotective and anti-trypanosomal activities.[5,6.] It has anti-anemic and hypoglycemic properties.[7] Its leafy parts are used in ethnopharmacology for the handling of heart problems, cough, wound dressing, and pulmonary defects.[8, 9]

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In spite of the huge opportunities in *Senecio biafrae* for nutrition and health, lack of planting materials, its slowing growing nature when compared with other leafy vegetables (especially when it is grown without fertilizers), poor awareness of its nutritional benefits, high labor cost, lack of agronomic management practices for its production, ageing of farmers and lack of finance for farmers to go into its production were some of the constraints to its production identified by Baiyeri *et al*.[10] They reported that intercropping it with other crops, irrigation, swamp planting, growing it all-year-round and fertilizer application were perceived by farmers as strategies for its sustainable production.[10]

The nutritional quality of crops (edible portions of crops) is largely influenced by several factors that include soil nutrition; since the roots of plants absorb and translocate needed nutrient elements to the various parts of the plant, including the leaves.[11] The use of either organic or inorganic fertilizer has merits and demerits on the soil, nutrient availability and plant development. Inorganic fertilizers usually have immediate effects and fast in the release of nutrients and they normally have important nutrient elements that are readily available for uptake by plants. Its continuous use however has negative effects on the environment that include the increase in soil acidity and degradation of the organic matter of the soil.[12] They are excellent sources of nitrogen and other nutrient elements in the production of crops. However, these conventional fertilizers are not always within the reach of smallholder farmers and soil acidity results when they are used over a long period of time. [13]

Organic fertilizers enhance the biological and physical capacities of the soil but have comparably low nutrient content; hence a lot is required for plant development. They are slow in the release of nutrients. [12] The integrated soil nutrient management system is a soil fertility management strategy that involves combining the application of organic and inorganic fertilizers. It is cost-effective and a

sustainable soil fertility management system that results in increased productivity, and improved soil fertility without severely affecting the environment. [12]

Fertilizers (organic and inorganic) have been reported to affect the nutritional qualities of fruits and vegetables.[11, 14, 15 16, 17, 18, 19, 20, 21] *Senecio biafrae* is a very slow-growing crop without the use of fertilizer.[22] Their research found that fertilizer enhanced the growth performance of *Senecio biafrae*.[22] There is currently a dearth of information on the effect of fertilizers on the nutritional and anti-nutritional composition of *Senecio biafrae* leaf in the literature. Farmers and consumers will better adopt fertilizer recommendations for the production of green leafy vegetables like *Senecio biafrae* if they have valid information on what will be the effect of the fertilizers on their nutritional and anti-nutritional composition. Most farmers and consumers of leafy vegetables in Nigeria believe that green leafy vegetables grown with fertilizers especially inorganic fertilizers are not healthy. There is a belief among these farmers and consumers that the nutritional contents of leafy vegetables grown with fertilizers are usually negatively affected. To allay the fears of consumers associated with consuming this vegetable when it is grown with fertilizers, and provide valid information on the effect of fertilizers on the antinutritional and nutritional composition of the leaves of the accessions of *Senecio biafrae*, this study was done. The objectives of this study were therefore to i) evaluate the effects of the cultivars (accessions) on the anti-nutrients and nutrients of the leaves of *Senecio biafrae* ii) investigate the effects of organic fertilizer (poultry manure), inorganic fertilizer (N.P.K.) and the combined effects of the application of the two fertilizers on the nutrients and anti-nutrient contents of the leaves of the accessions of *Senecio biafrae*.

Materials and Methods

Sample collection and experimental design

Fresh and tender leaves of two *Senecio biafrae* accessions were collected from *the Senecio biafrae* evaluation field in 2022.[22] The experiment was carried out at the Teaching and Research Farm of the Ikole-Campus of the Federal University, Oye-Ekiti (FUOYE), Ekiti State, Nigeria (07^0 48.159^{1}N, 005^0 29.623^{1}E; 564 m above sea level). The collected samples were assayed at the Analytical Laboratory of the Faculty of Agriculture, FUOYE.

The experimental design was a 2 x 4 factorial in a completely randomized design (CRD) with two replications. The treatments were: two accessions of *Senecio biafrae* (Odo-Oro and Orin-Odo) from Ekiti State, Nigeria, and four fertilizers: 100% N.P.K 15:15:15 (100 kg/ha), 100% poultry manure (PM) (5 tonnes/ha), 50% N.P.K + 50% PM (50 kg/ha NPK + 2.5 tonnes/ha PM) and control (no fertilizer applied). Odo-Oro and Orin-Odo were the cultivars (accessions) of *Senecio biafrae* that were selected for this experiment among the accessions of *Senecio biafrae* that were evaluated in an agronomic evaluation carried out in 2022. [22] Growth performances and the responses of Orin-Odo and Odo-Oro to various fertilizers have been reported by Baiyeri *et al.* [22] The main effects of each of the accessions and the main effects of each of the fertilizers applied on the nutritional (proximate and minerals) and the antinutritional parameters (phytate, oxalate, phenol and hydrogen cyanide) were studied. The combined (interaction) effects of the accessions and fertilizers applied on the nutritional and antinutritional parameters were also evaluated.

Proximate Analysis

The crude protein of the fresh *Senecio biafrae* leaves was determined using the Kjeldahl method (AOAC) 955.04. [23] The crude fat was determined by the acid hydrolysis method (AOAC) 954.02. [23] The crude fiber was determined using (AOAC) method 978.1. [23]

Minerals Determination

The mineral contents of the fresh leaves of the accessions of *Senecio biafrae* were determined using (AOAC) method 968.08.[23] Working standards of calcium, manganese, iron, potassium, magnesium, and sodium solutions were made from each of the minerals stock solutions of 100 mg/L. Blank was also prepared using the same volume of reagents used for digestion and filtration. The mineral concentrations in the digested fresh *Senecio biafrae* leaves samples were assayed using a Buck Scientific Atomic Absorption Spectrophotometer (Model: AA320 N) (China) at various wavelengths of the minerals and using specific cathode lamps of each minerals. The potassium and sodium contents of the fresh leaf samples were determined with a flame photometer (Model: FP640) (England).

Antinutrient Determination

The total phenolic compounds in the samples were determined according to Xu and Chang with slight modifications. [24] The hydrogen cyanide contents of the *Senecio biafrae* fresh leaf samples were determined using the alkaline picrate method with modifications. [25] Oxalate was determined using (AOAC) method 915.03. [23] The phytic acid contents were determined by the method of Abulude. [26]

Statistical analysis

All the *Senecio biafrae* nutritional and antinutritional data collected from the laboratory analyses of the fresh leaves of its accessions were analyzed using *R* statistical analytical software version 4.1.1 (2021). The analysis of variance was carried out using the library, agricolae. The significance of the treatment means was determined using Tukey's HSD test at a 95% confidence interval (5% probability level).

Results and discussion

Table 1 shows the main effect of accession and fertilizer on the proximate composition of the fresh leaves of *Senecio biafrae*. The proximate was significantly ($P<0.05$) affected by fertilizers. Orin-Odo produced numerically higher crude protein (4.21 %), crude fat (0.95 %), and crude fiber (1.15%) contents. The application of 100 % N.P.K 15:15:15 resulted in the highest crude protein content (4.41%), 100% poultry manure better enhanced the crude fat (0.98%) while the highest crude fiber content was recorded in the leaves of the plants that received 50% N.P.K + 50% poultry manure (1.20%). The combined effects of accession and fertilizer significantly affected the proximate (Table 2).

Orin-Odo and Odo-Oro grown with 100% N.P.K resulted in the highest crude protein (4.41%) while Orin-Odo grown with 50% N.P.K + 50% poultry manure produced the highest crude fat (1.06 %) and the highest crude fiber content (1.27%). The significant effects of both fertilizer and accession on the crude protein, crude fiber, and crude fat contents of the fresh leaves imply that the levels of these nutritional traits that will be obtained in *Senecio biafrae* leaf are largely determined by the type of fertilizer applied and its accession (cultivar) that is grown. The protein in the present study was higher than what Baiyeri *et al.* reported (1.76 - 2.29 %) in the fresh leaves of *Senecio biafrae* accessions collected from the wild from various locations in Ekiti state. [1]

Table 1: The main effects of accession and fertilizer on the proximate composition (%) of the fresh leaves of *Senecio biafrae*.

Treatment	Crude protein	Crude fat	Crude fibre
Accession Odo-Oro	4.19 ^{a}	0.93 ^{a}	1.14 ^{a}
Orin-Odo	4.21 ^{a}	0.95 ^{a}	1.15 ^{a}
Fertilizer			
Control	4.18 ^{b}	0.96 ^{a}	1.18 ^{a}
100% N.P.K	4.41 ^{a}	0.86 ^{b}	1.04 ^{b}
100% Poultry manure	4.12 ^{b}	0.98 ^{a}	1.17 ^{a}
50 % N.P.K + 50 % PM	4.10 ^{b}	0.97 ^{a}	1.20 ^{a}

Means followed by different letters are significantly different by a Tukey's HSD test at $\alpha = 0.05$.
PM = Poultry manure; N.P.K = Nitrogen Phosphorus Potassium (15:15:15); SD= standard deviation.

Table 2: The interaction effect of accession and fertilizer on the proximate (%) composition of the fresh leaves of *Senecio biafrae*.

Treatment		Crude protein	Crude fat	Crude fibre
Accession	Fertilizer			
Odo-Oro	Control	4.12 ^{c}	0.97 ^{a}	1.24 ^{a}
	100% N.P.K	4.41 ^{a}	0.89 ^{c}	1.02 ^{d}
	100% Poultry manure	4.08 ^{c}	0.98 ^{b}	1.15 ^{b}
	50 % N.P.K + 50 % PM	4.16 ^{bc}	0.89 ^{c}	1.13 ^{bc}
Orin-Odo	Control	4.25 ^{b}	0.95 ^{b}	1.11 ^{bc}
	100% N.P.K	4.41 ^{a}	0.82 ^{d}	1.05 ^{cd}
	100% Poultry manure	4.16 ^{bc}	0.97 ^{b}	1.19 ^{ab}
	50 % N.P.K + 50 % PM	4.04 ^{c}	1.06 ^{a}	1.27 ^{a}

Means followed by different letters are significantly different by a Tukey's HSD test at $\alpha = 0.05$. PM = Poultry manure; N.P.K = Nitrogen Phosphorus Potassium (15:15:15); SD = Standard deviation.

Table 3: The main effects of accession and fertilizer on the mineral composition (mg/100 g) of the fresh leaves of *Senecio biafrae*

Treatment	Na	K	Fe	Ca	Zn	Mg	Mn	P
Accession								
Odo-Oro	20.19 ^{a}	198.63 ^{b}	6.56 ^{a}	227.36 ^{a}	0.71 ^{b}	36.79 ^{a}	6.48 ^{a}	369.44 ^{a}
Orin-Odo	21.51 ^{a}	254.31 ^{a}	7.61 ^{a}	239.66 ^{a}	0.92 ^{a}	36.70 ^{a}	6.17 ^{a}	385.94 ^{a}
Fertilizer								
Control	21.68 ^{a}	245.63 ^{a}	7.22 ^{b}	256.06 ^{a}	0.81 ^{b}	37.53 ^{a}	4.62 ^{b}	397.38 ^{ab}
100% N.P.K	21.20 ^{a}	217.25 ^{a}	9.05 ^{a}	273.33 ^{a}	0.98 ^{a}	37.17 ^{a}	8.95 ^{a}	404.25 ^{a}
100%Poultry	20.21 ^{a}	223.88 ^{a}	6.23 ^{b}	207.48 ^{b}	0.76 ^{b}	36.04 ^{b}	5.85 ^{b}	374.50 ^{b}
Manure								
50%N.P.K+50% PM	20.30 ^{a}	219.13 ^{a}	5.85 ^{b}	197.19 ^{b}	0.71 ^{b}	36.23 ^{b}	5.89 ^{b}	334.63 ^{c}

Means followed by different letters are significantly different by a Tukey's HSD test at $\alpha = 0.05$. PM = Poultry manure; N.P.K = Nitrogen, Phosphorus, Potassium (15:15:15); SD= Standard deviation.

The improved protein content of the fresh leaves of the accessions of *Senecio biafrae* evaluated over the protein content of the fresh leaves of accessions of *Senecio biafrae* collected from the wild could have been due to improved crop management practices especially fertilizer application that better enhanced the growing conditions, hence, resulted in better nutritional contents when compared with the ones that grew in the wild with no crop management at all. This result agrees with Chechet and Charles that reported improved proximate composition of *Amaranthus cruentus* and *Amaranthus caudatus* that were gown with either organic or inorganic fertilizers over the control that recorded the lowest values for the proximate parameters studied. [18] Several studies have reported a strong association between the nutritional quality of crops with soil mineral nutrient content and genetic variation of the cultivars of the vegetables. [27]

The results of the main effect of accession and fertilizer on the mineral composition of the fresh leaves of *Senecio biafrae* are shown in Table 3. Fertilizer and accession significantly ($P<0.05$) affected the mineral compositions of the fresh leaves of *Senecio biafrae* accessions. This suggests that fertilizer usage and the type of cultivar of this vegetable grown will to a great extent influence the mineral contents of its leaves. The two accessions were not significantly ($P>0.05$) different in their sodium, iron, magnesium, manganese, and phosphorus contents. Interestingly, Orin-Odo recorded numerically higher values than Odo-Oro in sodium, potassium, iron, calcium, zinc, and phosphorus. The application of 100 % N.P.K consistently resulted in the significantly highest concentrations of all the minerals analyzed except the concentration of sodium and potassium that were not significantly influenced by fertilizer (control recorded numerically higher values). Earlier studies have also reported the effect of organic and inorganic fertilizers on the minerals of various fruits and vegetables. [14, 16, 17, 18, 19]

The interaction effect of accession and fertilizer on the mineral compositions of the fresh leaves of *Senecio biafrae* leaves are shown in Table 4. Orin-Odo when grown with the application of 100 % N.P.K resulted in the highest concentrations of sodium (23 mg/100 g), iron (10.48 mg/ 100 g), calcium (281.75 mg/ 100 g), zinc (1.16 mg /100 g) and manganese (10.37 mg/ 100 g). Hundred percent (100 %) N.P.K resulted in better mineral accumulation in the leaves. Most of the minerals (Fe, Zn, Mn, Na, and P) were significantly higher than the control when Orin-odo was grown with fertilizers (100% of either poultry manure or N.P.K). Orin-Odo when grown with fertilizers was superior in mineral concentrations than when Odo-Oro was grown with fertilizers, suggesting variation in the nutrient mining capacity of the accessions for plant nutrients in the soil that could have influenced their mineral compositions. The highest concentration of Mg, K, and P in the Orin-Odo control further suggests the superior nutrient mining capacity of this accession over Odo-Oro. There may be morphological characteristics of Orin-Odo such as longer roots, larger root volume, and root weight that could have been responsible for the results obtained. The concentration of phytonutrients in green leafy vegetables has been reported to be influenced by factors such as genotypic characteristics, crop management practices, and climatic and edaphic (soil) factors. [28] Generally, the minerals studied in the fresh leaves were better than what had been reported for the same accessions when they were collected in the wild with no fertilizers applied in their production.[1] This suggests that there is the need for improved crop management practices including fertilizer application for the production of this vegetable crop for an enhanced nutritional quality of its leaves. Hence, it should not just be left in the wild but domesticated and brought into the regular cropping systems to avert the loss of its genetic biodiversity and its extinction. It is worth noting

that the fresh leaves of *Senecio biafrae* accessions evaluated in this study have demonstrated superior mineral composition more than what have been reported for the leaves of six leafy vegetables by Garcia-Herrera *et al.*, bitter leaf by Ojimelukwe and Amaechi and four indigenous vegetables by Halilu and Addis. [28,29,30]

The main effect of fertilizer on the anti-nutritional composition of the fresh leaves of *Senecio biafrae* is shown in Table 5. The antinutrients were not significantly (P>0.05) different in the accessions, except polyphenol that significantly (P<0.05) varied and was higher in Orin-Odo (23.56 mg/100 g). Fertilizer significantly affected the oxalate and phytate compositions of the fresh leaves of the vegetable but not polyphenol and hydrogen cyanide. The application of 100 % N.P.K resulted in the highest oxalate (0.87 mg/100 g) and phytate (1.37 mg/100 g). Control also recorded (1.37 mg/ 100 g) for phytate. No fertilizer application (control) (23.50 mg/100 g) resulted in numerically (P>0.05) higher polyphenol. Poultry manure caused significantly lower concentrations of oxalate (0.80 mg/100 g) and phytate (1.28 mg/100 g) (Table 5). The interaction effect of accession and fertilizer significantly (P<0.05) influenced the antinutrients in the fresh leaves (Table 6). Concerning the concentration of antinutrients in the leaves, the two *Senecio biafrae* accessions showed varied responses to the various fertilizers applied. The fresh leaves produced by the combined effects of Orin-Odo and 100 % poultry manure resulted in the highest concentrations of polyphenol (23.80 mg/ 100 g) and HCN (0.25 mg/100 g). Orin-Odo when grown with N.P.K resulted in the highest concentration oxalate (0.92 mg/100 g) and phytate (1.44 mg/100 g). The combined effects of Odo-Oro and 100% N.P.K resulted in the lowest concentration of polyphenol (20.23 mg/ 100g) and oxalate (0.82 mg/100 g) while Odo-Oro when grown with 100 % poultry manure and 50% poultry manure + 50% N.P.K resulted in the lowest accumulation of phytate (1.29 mg/100 g) and HCN (0.21 mg/100 g). The fertilizers applied did not increase the antinutrients to levels that were outrageously above the levels observed in the control, implying that the application of fertilizer in the production of the vegetable may not significantly increase the anti-nutrients in the leaves and should be encouraged for its production. The leaves of *Senecio biafrae* had low anti-nutrient concentrations that were lower than what has been recorded for polyphenol, oxalate, phytate, and hydrogen cyanide in the leaves of vegetables used in the preparation of soups. [31,32] Antinutrients are not generally high in green leafy vegetables that have been reputed for their food and nutritional values. Food processing methods such as cooking, steaming, boiling, frying, and fermenting have been reported to reduce them to safe levels and make them fit for human consumption.[33] Although antinutrients have been understood to negatively affect the absorption of nutrients in foods, recent studies have revealed their health-impacting effects, especially in low concentrations. Their health benefits include antioxidant and anticarcinogenic effects, and the ability to bind toxic metals such as cadmium and palladium or excess iron. [34,35] Baiyeri *et al*. have noted that antinutritional factors in edible green vegetables such as *Senecio biafrae* should not be major concerns about their consumption, absorption, and bioavailability of the nutrients they have in them since the various food preparation methods are effective in reducing them to very minimal and healthy levels. [1] Nutrient-density has been reported by researchers in edible portions of underutilized crops. [36,37] The huge opportunities in these invaluable crops should be maximized for human nutrition, health, and income generation.

Conclusion

Fertilizer and accession significantly affected the proximate, minerals and antinutrients of the fresh leaves. This indicates that the levels of nutrients and antinutrients in the fresh leaves of *Senecio biafrae* are largely determined by the accession grown and the type of fertilizer applied during its production. Orin-Odo demonstrated superior nutrient quality. The fertilizers enhanced the nutrients and did not significantly increase some of the antinutrients higher than the control. This implies that the application of fertilizer in the production of *Senecio biafrae* may not significantly increase its anti-nutrients in its leaves and should be encouraged for its production.

Conflict of Interest

The authors declare no conflict of interest.

Authors' Declaration

The authors hereby declare that the work presented in this article is original and that any liability for claims relating to the content of this article will be borne by them.

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Table 4: The interaction effect of accession and fertilizer on the mineral composition (mg/100 g) of the fresh leaves of *Senecio biafrae*

Treatment		Na	K	Fe	Ca	Zn	Mg	Mn	P
Accession	Fertilizer								
Odo-Oro	Control	21.35 ^{ab}	216.00 ^{d}	6.66 ^{bc}	230.83 ^{bc}	0.67 ^{d}	36.99 ^{bc}	5.74 ^{cd}	378.00 ^{bc}
	100% N.P.K	19.40 ^{b}	198.50 ^{e}	7.62 ^{b}	264.90 ^{ab}	0.79 ^{c}	37.35 ^{ab}	7.53 ^{b}	399.00 ^{ab}
	100% PM	20.05 ^{ab}	188.75 ^{e}	6.64 ^{bc}	205.20 ^{c}	0.71 ^{d}	36.01 ^{cd}	5.89 ^{cd}	359.00 ^{cd}
	50% N.P.K+ 50% PM	19.95 ^{ab}	191.25 ^{e}	5.31 ^{c}	208.53 ^{c}	0.68 ^{d}	36.81 ^{bc}	6.77 ^{bc}	341.75 ^{de}
Orin-Odo	Control	22.00 ^{ab}	275.25 ^{a}	7.78 ^{b}	281.30 ^{a}	0.95 ^{b}	38.08 ^{a}	3.51 ^{e}	416.75 ^{a}
	100% N.P.K	23.00 ^{a}	236.00 ^{c}	10.48 ^{a}	281.75 ^{a}	1.16 ^{a}	37.00 ^{bc}	10.37 ^{a}	409.50 ^{a}
	100% PM	20.38 ^{ab}	259.00 ^{b}	5.81 ^{bc}	209.75 ^{c}	0.81 ^{c}	36.08 ^{cd}	5.81 ^{cd}	390.00 ^{ab}
	50% N.P.K+ 50% PM	20.65 ^{ab}	247.00 ^{bc}	6.39 ^{bc}	185.85 ^{c}	0.74 ^{cd}	35.65 ^{d}	5.01 ^{de}	327.50 ^{e}

Means followed by different letters are significantly different by a Tukey's HSD test at α = 0.05. PM = Poultry manure; N.P.K = Nitrogen, Phosphorus, Potassium (15:15:15); Na = sodium; Fe = Iron; Ca = calcium; k = Potassium; Zn = zinc; Mg = magnesium; Mn = manganese; P= phosphorus; SD= standard deviation.

Table 5: The main effects of accession and fertilizer on the anti-nutritional composition (mg/100 g) of the fresh leaves of *Senecio biafrae.*

Treatment	Polyphenol	Oxalate	Phytate	HCN
Accession				
Odo-Oro	21.50 [b]	0.83 [a]	1.33 [a]	0.21 [a]
Orin-Odo	23.56 [a]	0.83 [a]	1.35 [a]	0.22 [a]
Fertilizer				
Control	23.50 [a]	0.81 [bc]	1.37 [a]	0.22 [a]
100% N.P.K	21.84 [a]	0.87 [a]	1.37 [a]	0.21 [a]
100% Poultry Manure	22.53 [a]	0.80 [c]	1.28 [b]	0.23 [a]
50% N.P.K+ 50% PM	22.27 [a]	0.86 [ab]	1.34 [ab]	0.21 [a]

Means followed by different letters are significantly different by a Tukey's HSD test at α = 0.05 .PM = Poultry manure; N.P.K = Nitrogen, Phosphorus, Potassium (15:15:15); HCN = Hydrogen cyanide; SD= standard deviation.

Table 6: The interaction effect of accession and fertilizer on the anti-nutritional composition (mg/100 g) of the fresh leaves of *Senecio biafrae*

Treatment		Polyphenol	Oxalate	Phytate	HCN
Accession	Fertilizer				
Odo-Oro	Control	23.55 [a]	0.83 [bcd]	1.40 [ab]	0.22 [ab]
	100% N.P.K	20.23 [b]	0.82 [cd]	1.30 [c]	0.21 [ab]
	100% Poultry Manure	21.25 [b]	0.84 [bcd]	1.32 [bc]	0.21 [b]
	50% N.P.K+ 50% PM	20.99 [b]	0.86 [b]	1.29 [c]	0.21 [b]
Orin-Odo	Control	23.45 [a]	0.80 [de]	1.33 [bc]	0.22 [ab]
	100% N.P.K	23.45 [a]	0.92 [a]	1.44 [a]	0.21 [b]
	100% Poultry Manure	23.80 [a]	0.76 [e]	1.25 [c]	0.25 [a]
	50% N.P.K+ 50% PM	23.55 [a]	0.85 [bc]	1.39 [ab]	0.22 [ab]

Means followed by different letters are significantly different by a Tukey's HSD test at α = 0.05. PM = Poultry manure; N.P.K = Nitrogen, Phosphorus, Potassium (15:15:15); HCN = Hydrogen cyanide; SD= standard deviation.

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