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Effect of Sun-Drying and Oven-Drying Processing Methods on the Chemical Composition of Bitter Leaves (*Vernonia amygdalina*)

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Abstract

Leafy vegetables, commonly consumed as edible plant shoots, are rich sources of macro- and micronutrients. *Vernonia amygdalina* (bitter leaves) is a widely consumed vegetable in Nigeria, especially among the Igbo community, where drying—either by sun or oven—is a prevalent preservation method that also enhances taste. This study investigates the effects of sun-drying and oven-drying on the chemical composition of *Vernonia amygdalina* leaves. Approximately 2.5 kg of fresh leaves were purchased from Watt Market, Calabar (South-South Nigeria), destalked, and divided into three equal portions. One portion was used as a control (fresh, unprocessed), while the other two were subjected to one-month drying treatments—sun-drying and oven-drying—before being pulverized into flours, sealed in airtight containers, and stored under cool, dry conditions. Standard analytical procedures were employed to assess proximate composition, elemental content, and phytochemical properties. Results revealed that both drying methods significantly reduced moisture content, leading to an increase in dry matter. Notably, the sun-dried samples showed increased ash ($6.32 \pm 0.02\%$ vs. $2.45 \pm 0.02\%$ in control) and crude protein ($6.23 \pm 0.02\%$ vs. $5.40 \pm 0.1\%$), while oven-dried samples exhibited elevated crude fat ($3.33 \pm 0.2\%$), crude fibre ($14.30 \pm 0.1\%$), and carbohydrate content ($52.10 \pm 0.01\%$) compared to the control. Conversely, drying led to reductions in vitamin levels, mineral content, antinutrients, and food toxicants. These findings indicate that drying improves the nutritional density of macronutrients while decreasing potentially harmful components, thus enhancing the digestibility and safety of the leaves. The study concludes that sun and oven-drying are effective preservation techniques that significantly influence the nutritional profile of *Vernonia amygdalina*, with important implications for food security and dietary quality.

Keywords: Leafy Vegetables; *Vernonia amygdalina*; Sun-Drying; Oven-Drying; Nutritional Composition

INTRODUCTION

Bitter-leaves (*Vernonia amygdalina* leaves) are dark green-leafy-vegetables (Udoh, 2025[a]), found in the wild or grown and consumed in many parts of Africa. Idowu (2008), reported that vegetables are consumed to help build up and repair the body. The researcher further added that vegetables when consumed in sufficient quantities are also responsible for maintaining the body's alkalinity. According to Idowu (2008) they are composed of micronutrients such as minerals, vitamins, and macronutrients like fibres, proteins, carbohydrates, and some hormones precursors. Oboh and Madojemu (2010), added that bitterleaves are tropical shrubs widely consumed in Nigeria, and are **known** by various names like; "bitter leaf (English), oriwo (Edo), ewuro (Yoruba), shikawa (Hausa), and olubu (Igbo)". Odukoya *et al.* (2019) stated that bitter leaves are used in the preparation of soups such as 'Ogbono' soup and 'Ndole' dish in Nigeria and Cameroun respectively. Bitter leaves are also used for melon soup, as well as water leaves soup, amongst others.

Bitter leaves are also popularly consumed due to their nutritive vales and other medicinal benefits. Akubugwo *et al.* (2007), stated that vegetables provide the recommended dietary allowances of essential nutrients that are needed for normal body tissues' metabolic activities. The micronutrients found in vegetables also aids digestion. Bitter leaves have a distinct odour and bitter taste (Georgewill and Georgewill, 2010, Farombi and Owoeye, 2011). This leaves also help in cleansing and detoxifying the body, especially when taken as a juice or as enema. Odukoya, *et al.* (2019) had documented that the usefulness of bitter leaves (*Vernonia amygdalina* leaves) included the medicinal properties of its phytochemicals. They stated that bitter leaves phytochemicals such as flavonoids and alkaloid are used traditionally to treat malaria, diabetes, and inflammatory diseases. According to Yeap *et al.* (2010) and several other researchers' bitter leaves are usually crushed, or soaked, or boiled before they are washed several times with clean water to remove some of its bitterness. At other times, they are dried, especially by the Igbos in Nigeria to enhance its taste (Udoh, 2025[a]), reduce the bitterness, as well as preserve the leaves (Udoh, 2025[b]).

Yang and Tson (2006) documented that thermal treatment (example, drying) helps enhance bitter leaves' micronutrients bioavailability, because the embedded antinutrients in the leaves are reduced during such treatment, liberating some bound minerals. Udoh *et al.* (2025), and Liman *et al.* (2014) reported that drying of vegetables became necessary due to the scarcity or absence of vegetables in the dry season. Ijeh and Ejike (2011) noted that bitter leaves' plant is tolerant to drought compared to many other commonly consumed vegetables in Nigeria but needs processing after harvest to preserve it. Mepha *et al.* (2007) and Udoh (2025[a]) documented that vegetables after harvest are highly perishable, therefore required processing to reduce post-harvest losses. The drying of vegetables especially by 'sun-drying' is commonly used my many people to preserve vegetables. Other drying techniques such as oven drying, freeze-drying, amongst others are also gaining popularity in Nigeria in many homes.

Drying vegetables is known to continually add variety to food menu. Oguche (2011), stated that the production of green leafy vegetables by farmers are not favoured like other agricultural products perhaps due to great post-harvest losses experienced. Therefore, the need to preserve vegetables during its session of abundance is paramount, to address the risk of malnutrition, especially among children at risk communities. Mosha and Gaga (1999), AOAC (2000), Udofia and Obizoba (2005), also added that vegetables when dried ensure availability of essential nutrients in daily diets, especially in at-risk rural dwellers meals where micronutrients and macronutrients are often in short supply.

Kiremire *et al.* (2010) reported that vegetable processing or preservation via the traditional method such as sun drying leads to nutrient loss. They confirmed that micronutrients such as minerals and vitamins are reduced in value, but there are considerable increase in macronutrients. Antinutrients and food toxicants are reduced in dried vegetables, making vegetables to be easily utilised by the body for good health. Therefore, it is advised that vegetables should be consumed in much quantity to compensate for the losses that are observed during vegetable processing/treatment.

MATERIALS AND METHODS

Various materials and techniques/methods were employed in the different analyses done. They are as follow:

Collection and identification of plant materials

Bitter-leaves (*Vernonia amygdalina leaves*) that were disease-free were identified and purchased from Calabar Watt-Market in Cross River, Nigeria.

Study area and design

This study was conducted in Biochemistry Department of the University of Calabar, Calabar, Cross River, Nigeria. It was conducted to identify the effect of sun-drying and oven-drying processing methods on *Vernonia amygdalina leaves*' chemical composition.

Preparation of plant materials

Bitter-leaves (*Vernonia amygdalina leaves*) that were purchased was washed thoroughly to free it of sand and dirt which could lead to contamination. The bitter-leaves were afterwards shared into three equal parts. The first two parts were processed (sun-dried and oven-dried) for one month, whereas the remaining one part of the shared bitter leaves did not receive any treatment (served as control). All the dried leaves samples were pulverized separately into flours with an electric blender. Each of the two pulverized samples were separately put into two different airtight vessels with cover, and kept in it until it time for analysis.

Laboratory analysis of samples

Three different laboratory analyses was used for investigate the proximate composition, elemental composition and phytochemical composition of the dried bitter-leaves (*Vernonia amygdalina leaves*) following various standard analytical methods.

Proximate composition analysis

The proximate composition of the pulverized sun-dried and oven-dried samples was done using the AOAC (Association of the Official Analytical Chemists) standard methods for proximate composition analysis.

Brief breakdown of the analyses carried out:

i. ***Moisture content determination*** (AOAC, 2000)

Approximately two grams of each pulverised bitter leaves samples were weighed and put into a dried weighed moisture dish. They were then placed in an air-oven at 70^0C to dry further at a constant weight. The weight loss after desiccator's cooling for 65 minutes was used as the moisture content.

ii. ***Ash determination*** (AOAC, 2000)

Two grams each of the two pulverised bitter-leaves samples were weighed and was put into a porcelain crucible whose weight is known and covered. The next step involved the porcelain crucible with its contents being ignited at 525^0C for 24hours. The ash content was determined by measuring the weight of ash in the crucible. This was carried out three times for each sample.

Calculation

Ash (% dry weight) = Weight of ash in grams × 100

Weight of sample

iii. ***Crude Protein content estimation through total Nitrogen (Macro Kjeldahl method)*** (AOAC, 2000)

A gram of each bitter-leaves samples that were pulverised were placed separately in different digestion flasks. This was done in triplicate. Anhydrous sodium sulphate of 96% and copper sulphate catalyst mixture of 3.5% were added to the samples. Digestion of the samples was done using concentrated sulphuric acid, before the flasks were cooled. The sides of the flasks were rinsed using de-ionized water. Digestion was continued for an additional one hour before transferring into a distillation apparatus. The distillation was done with a 10ml of de-ionized water and 15ml of 45% sodium hydroxide. Ammonia was released, and steam-distilled into 10ml of 5% boric acid solution in which 4 drops of methyl-red-methylene blue indicator had been put into. The distillation continued until 20mlvolume of the receiving flask was reached. The ammonium borate complex was produced and diluted to 50ml. The mixture was titrated with 0.02N HCl until a pink end point was established. Another distillation was done using a blank (no sample was put into the digestion flask), but the other procedures were followed.

The percentage (D/W) of nitrogen in sample was then calculated as follows:

ml of HCl (sample) – ml of HCl (blank) × 14 ×100

Wt. of sample in gm × 1000

1g = 1000mg (to offset the titre values which are in millilitres)

Crude protein was estimated by multiplying the percentage nitrogen by the factor 6.25.

Crude Protein = Percentage of nitrogen × 6.25

iv. ***Crude Fat content (Petroleum ether extract)*** (AOAC, 2000)

For each of the pulverised samples five grams (5g) were accurately weighed and put into a continuous Soxhlet extractor treated with petroleum ether extraction for defatting. Evaporation of the ether was done to obtain the fat content (leaving the lipid extract), and this was determined by weight. This was done in triplicate.

Calculation

Petroleum ether extract (% dry weight) = Weight of extract (g) × 100

Weight of dry sample

v. ***Crude Fibre content***

The 3.50g of fat-free material of each of the pulverised samples for crude fibre estimation was subjected in a known sequence to 1.25% sulphuric acid with 1.25% sodium hydroxide extraction digestion. The residue obtained after each digestion was dried at 105^0C, before their weight were taken. Immediately afterwards the incineration at 550^0C to ash was done.

The weight loss was taken as the crude fibre content. This was done in triplicate for each sample.

% Crude fibre content = Weight of ash in crucible after ignition × 100

Weight of sample

vi. ***Carbohydrate content***

The carbohydrate content of each bitter leaves pulverised samples was determined by simply summing up the values for moisture content, total ash, crude protein, crude fat and crude fibre, before subtracting the value obtained from 100g.

Estimation of Mineral Elements

i. Estimation of Calcium (AOAC, 2000)

An acidic state of calcium was done by digesting 2.0g of each of the bitter leaves samples that were pulverised in a mixture of 25ml concentrated sulphuric acid and 5ml per-chloric acid separately. Aliquots of each pulverized samples was achieved through dilutions and were subjected to flame photometry. At 626nm on the photometry, the calcium content of each sample was measured. A prepared calibration curve of standard solutions of calcium carbonate, was used to estimate the concentration of calcium.

ii. ***Estimation of Phosphorus (Molybdovanadate Method)*** (AOAC, 2000)

A fraction from the acidic digest gotten from calcium determination was used for the determination of phosphorus. Only suitable aliquots were taken and was reacted with molybdovanadate reagent until a pink colour complex of phosphor-molybdovanadate was seen. The next step involved the quantification of the developed colour using a colorimeter at 400nm. The concentration of Phosphorus was estimated using the potassium hydrogen phosphate (KH_2PO_4) prepared standard curve.

Estimation of Antinutrients

i. ***Estimation of Phytates*** (Finglas *et al.*, 2014)

Five grams (5g) of each pulverized sample was extracted to get phytic acid with 0.5N hydrochloric acid. The extracted phytic acid for each was separately precipitated to ferric phytate, using ferric chloride. Sodium hydroxide was reacted with ferric phytate to convert it to sodium phytate. Each sample phosphorus content was quantified after adding molybdate colour development solution using a colorimeter at 620nm.

ii. ***Estimation of Hydrogen Cyanide content*** **(**AOAC, 2000**)**

Eight grams (8g) of each sample was liberated after soaking it in water for about 4 hours to obtain their cyanide content. The liberated cyanide found in the water was extracted through steam distillation into 20ml 2.5% NaOH, having the addition of 8ml 6N ammonium hydroxide and 2ml 5% potassium iodine. The result was titrated with 0.02N silver nitrate until a permanent but faint turbidity followed.

(1.0ml of 0.02N $AgNO_3$ = 1.08mg HCN)

iii. ***Estimation of Total Oxalates*** **(**Dye, 1956**)**

Each pulverized sample of five grams (5g) weight was digested at 37^0C in a 200ml distilled water and 6N hydrogen chloride. The oxalate obtained was precipitated with calcium chloride to calcium oxalate. A 25% sulphuric acid and dissolved in 100ml water was used to wash the oxalate before titrating it against 0.05N potassium permanganate. This was stopped immediately a purple end point that persisted for about 15 seconds was reached.

(1.0ml $KMnO_4$ = 2.20mg oxalate)

iv. ***Estimation of Soluble Oxalates*** **(**Dye, 1956**)**

Each pulverized sample of five grams (5g) weight was digested at 90^0C for approximately 4 hours in 200ml distilled water and 6N hydrogen chloride. The obtained digest was subjected further to the same procedure explained in total oxalate.

(1.00ml $KMnO_4$ = 2.20mg oxalate)

Data/Statistical analysis

The obtained data for this study were expressed as mean ± standard error of the three replicates done. The data were also subjected to analysis of variance (ANOVA) using a statistical analysis package (SPSS version 22.0, Chicago, IL, USA). The means obtained were separated following the Duncan's Multiple Range Test (DMRT) at a significance level of 5%. Associations between variables were taken as statistically significant at p-values less than, or equal to 0.05 ($p \leq 0.05$).

RESULTS

The tabulation of the various analyses results that were obtained from bitter-leaves' (*Vernonia amygdalina* leaves) proximate composition, elemental composition and phytochemical analysis screening is placed in Tables 1 to 5.

Proximate Composition

The proximate analysis carried out on fresh, sun-dried and oven-dried bitter-leaves (*Vernonia amygdalina* leaves) samples are presented in Table 1. Drastic moisture reduction during treatment was experience, compared to the fresh sample. Ash content on the other hand was significantly increased in dried samples, compared with the fresh leaves. In this study, the estimated lipid content was greatly higher ($P<0.05$) in the dried samples than the control. The protein value is increased in sun-dried sample but reduced in oven-dried sample when compared to the control in this study. The carbohydrate and fibre content for this study were significantly higher ($p<0.05$) in all dried samples compared to the fresh samples.

Elemental Composition

The elemental composition analysis results of fresh, sun-dried and oven-dried of bitter-leaves (*Vernonia amygdalina* leaves) are found in Table 2. This study experienced great mineral losses during drying. Hence, mineral contents in vegetables are very sensitive to heat. Percentage loss for each of the analysed elements as shown in Table 3. Percentage loss in mineral contents was more than 50% mostly in oven-dried samples.

Phytochemical Screening

Phytochemical analysis results of analysed fresh, sun-dried and oven-dried bitter-leaves (*Vernonia amygdalina* leaves) samples are presented in Table 4. This study shows that most food toxicants and anti-nutrients found in food are reduced on heat application. The higher the heat application intensity, the higher the reduction in the amount of food toxicants and anti-nutrients left, compared to the control. Phytic acid was the most prominent phytochemical found in the bitter-leaves analysed in this study, with value ranging from 1.89±0.02 (fresh sample) to 1.69±0.01 (sun-dried sample), and 1.64±0.01 (oven-dried sample). Other phytochemicals found in bitter-leaves are presented in Table 5.

Table 1: Proximate Composition of fresh, Sun-dried and Oven-dried bitter-leaves (*Vernonia amygdalina leaves*) (%)

S/N	Name of sample	Moisture	Ash	Crude Protein	Crude Fat	Fibre	Carbohydrate
1	Fresh *Vernonia amygdalina* leaves	83.16± 0.01	2.45 ± 0.02	5.40 ± 0.1	2.30 ± 0.1	2.84 ± 0.01	3.85 ± 0.02
2	Sun-dried *Vernonia amygdalina* leaves	25.40 ± 0.1	6.32 ± 0.02	6.23 ± 0.02	2.60 ± 0.1	10.45 ± 0.02	49.00 ± 0.02
3	Oven-dried *Vernonia amygdalina* leaves	19.45± 0.02	6.30 ± 0.1	4.52 ± 0.02	3.33 ± 0.2	14.30 ± 0.1	52.10 ± 0.01

Each value represents mean of 3 determinants ± SD

Table 2: Elemental Composition of fresh, sun-dried and oven-dried bitter-leaves (*Vernonia amygdalina* leaves) (mg/100g dry matter)

S/N	Name of sample	Na	P	K	Ca	Mg	Fe	Cu	Zn
1	Fresh *Vernonia amygdalina* leaves	8.30	2.06	4.50	2.24	2.80	7.50	1.03	2.39
2	Sun dried *Vernonia amygdalina* leaves	7.60	1.90	3.83	1.08	1.45	6.20	0.95	1.05
3	Oven dried *Vernonia amygdalina* leaves	6.34	0.67	1.73	0.94	0.65	4.31	0.43	0.31

Table 3: Percentage Loss in Elemental Composition of Processed Sample (sun-dried and oven-dried) of bitter-leaves (*Vernonia amygdalina* leaves) (%)

S/N	Name of sample	Na	P	K	Ca	Mg	Fe	Cu	Zn
1	Sun-dried *Vernonia amygdalina* leaves	8.43	7.77	14.89	51.79	48.21	17.33	7.77	56.07
2	Oven-dried *Vernonia amygdalina* leaves	23.61	67.48	61.11	58.04	76.79	42.53	58.25	87.03

Table 4: Results of Phytochemical Screening of fresh, sun-dried and oven-dried bitter-leaves (*Vernonia amygdalina* leaves)

S/N	Chemical constituents	Fresh *Vernonia amygdalina* Leaves		Sun dried *Vernonia amygdalina* Leaves		Oven dried *Vernonia amygdalina* Leaves	
		Ethanol extract	Aqueous extract	Ethanol extract	Aqueous extract	Ethanol extract	Aqueous extract
1	Alkaloids	+	+	-	-	-	-
2	Cyanogenic Glycosides (Hydrocyanic acid)	++	+	++	+	+	+
3	Saponins	+++	++	++	+	+	++
4	Tannins	+	-	+	-	+	-
5	Flavonoids	+	-	-	-	+	-
6	Oxalates	++	+	++	++	+	++
7	Phytic acid	+++	++	++	++	++	+
8	Phlobatanins	-	-	-	-	-	-

9	Anthroquinons	-	-	-	-	-	-
10	Hydroxymethyl anthraquinons	-	-	-	-	-	-

Key

Presence	+
Presence in excess	++
Presence in much excess	+++
Absent	-

Table 5: Results of Quantitative Analysis of Prominent Phytochemicals in fresh, sun-dried and oven-dried bitter-leaves (*Vernonia amygdalina* leaves)

Sample	Phytic acid (mg/g)	Hydrocyanic acid (mg/g)	Saponins (mg/g)	Total Oxalates (mg/g)	Soluble Oxalates (mg/g)
Fresh *Vernonia amygdalina* leaves	1.89±0.02	0.14±0.02	1.84±0.02	1.79±0.01	0.43±0.01
Sun dried *Vernonia amygdalina* leaves	1.69±0.01	0.12±0.02	1.69±0.01	1.67±0.02	0.41±0.01
Oven dried *Vernonia amygdalina* leaves	1.64±0.01	0.11±0.02	1.66±0.02	1.59±0.02	0.37±0.01

DISCUSSION

Drying as a processing method has helped in the preservation of various fresh fruits, vegetables, herbs, meat and fish. Vegetables are needed for the provision of micronutrients and macronutrients, especially in many at-risk communities (Udoh *et al.*, 2025). This is one of the most important reasons that vegetables are dried. The different drying processing methods has several detrimental and beneficial effects on the chemical composition of vegetables. Several researchers have over the years reported that the most detrimental effect of drying processing methods on vegetables is on the minerals and vitamins contents. This is because drying tend to increase micronutrients loss. Oguche (2011), confirmed that vegetables that are dried, experience increased nutrient loss. Morris and Burrows, (2004) added that drying although increases micronutrients loss, generally improves digestibility of foods. It also increases the concentration of macronutrients, as well as make some nutrients readily available (Udoh *et* al., 2025).

Matazu and Haroun (2004), and Hassan *et al.* (2007) added that reduction of moisture content in fruits and vegetables offsets the environment which was previously suitable for micro-organisms growth. Hence, drying makes preservation of the leaves possible. Heat treatment by drying also help in inhibiting autolytic enzymes reported Ladan *et al.* (1996). Drying increases ash content of vegetables (Udoh, 2025[a]). Ash content is an index which is used to estimate the total mineral element present in a food item. Gallali *et al.* (2000) documented that ash value give insight of the item's level of sand contamination from the surrounding. Protein is usually decrease upon heat application (such as drying) reported Morris and Burrows (2004). Oguche (2011) further added that dried vegetables have decreased phytochemicals compared to fresh vegetables which is vital for good health. Phytochemicals such as tannin, phytate, among others in dried vegetables are lower in values than that of fresh vegetables.

Drying processing method often accelerates the rate of oxidation of nutrients. Moisture which is important for further microbial and enzymatic activities on harvested vegetables are reduced in dried vegetables than those of fresh vegetables. Sun-dried samples tends to have more moisture content than oven-dried samples. In this study the moisture value of bitter-leaves (*Vernonia amygdalina* leaves) is greatly reduced, helping in the preservation of the dried vegetable. Ash content and the macronutrients (proteins, fats, carbohydrates, fibre) values of dried samples of this study had considerably increased, except oven-dried sample's crude protein (Table 1). In this study's elemental composition analysis of bitter-leaves (*Vernonia amygdalina* leaves), sodium, calcium, phosphorus, magnesium, copper, iron, zinc and potassium values for the dried samples had lower values than the fresh vegetables (Table 2). This is in support of the claim made by Udoh *et* al. (2025), Udoh (2025[a]), Udoh (2025[b]), Chweya and Eyzaguirre (1999), and many other researchers that drying reduces mineral contents (that is reduces micronutrients) in dried vegetables.

This imply that vegetables need to be consumed regularly in much quantities for sufficient amount of micronutrients to be obtained. This is because most vegetables are not consumed raw. Example, calcium content in the dried bitter-leaves (*Vernonia amygdalina* leaves) samples analysed in this study was reduced from 2.24mg/100g (fresh sample) to 0.94mg/100g (oven-dried samples). Ladan *et al.* in 1996, had stated that calcium and potassium were needed in sufficient amount for good muscles, bone, and teeth development. They also added that the two stated minerals are linked with the metabolism of vitamin D. Other micronutrients present in vegetables have several crucial roles, such as zinc involved in; boosting the immune system (Bhaskaram, 2002), just like vitamin C, zinc is also vital for the secretion of insulin (Chausmer, 1998), and vitamin A release from the liver (Hwang *et al.,* 2002), as well as an enzyme (Boron *et al.,* 1988). Vitamin A help in good eye sights, iron for good blood formation and transport, amongst others.

Phytochemicals of bitter-leaves (*Vernonia amygdalina* leaves) in this study just like many other leaves reduced considerably, especially in oven-dried samples. Phytic acid was the phytochemical with highest values across the three samples (fresh, sun-dried and oven-dried) analysed. Therefore, intense heat application (oven drying) is a better option for processing vegetables with very high amounts of antinutrients and food toxicants. Whereas milder heat application (sun drying), is better for micronutrients conservation for vegetables with lower amounts of antinutrients and food toxicants. This is because antinutrients tend to hinder nutrients' availability and utilisation, while food toxicants can cause illnesses or diseases such as; stomach upsets, stomach bloating, colon diseases, even colon cancer, among others. Hence, it is advisable to use a drying processing method that best suits the vegetable of interest to ensure all year round supply of essential food nutrients to all, especially children that are at risk of malnutrition in hard to reach and/or at risk rural communities.

Conclusion

Vegetables are vital for good health, as they provide essential nutrients lacking in many diets consumed in many homes. Drying vegetables are important for its preservation, especially when they are in excess during the light rains. This is because vegetables grow very well during the light rains, and can be easily cultivated and even distributed then. The problem of vegetable cultivations and distributions begin to develop during the very heavy rains and dry seasons when they grow poorly. The very bad roads during the heavy rains makes it even harder to take vegetables to some at-risk communities. Hence, vegetables are advised to be consumed in large quantities fresh or not over cooked if one expects to obtain sufficient micronutrients from it during its period of abundance. Soft loans should be given to farmers by the government or philanthropists to encourage extensive vegetable cultivations, distributions, and processing (preservation). Excess vegetables should be processed (example by drying) to ensure its availability during the heavy rains and dry seasons. This will ensure that malnutrition is eradicated in the developing countries, especially in Nigeria. This is due to the fact that the majority of individuals living in Nigeria presently cannot afford nutrient supplements and/or fortified foods sold in the market, to supplement their meals deficiencies.

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Authors' Roles/Participation in the Authorship of the Manuscript:

i. **Mary Athanasius Udoh (Corresponding Author):** substantial contributions to the conception and design of the work, acquisition of data, analysis and interpretation of data, drafting the work, final approval of the version to be published.

ii. **Augustina Elochukwu Ijezie**: acquisition of data, analysis and interpretation of data, final approval of the version to be published.

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