Phytochemicals, *in vitro* bioavailability of Beta carotene and anti-nutrient composition of Some Neglected Underutilized Green Leafy Vegetables and Fruits in South East Geo-Political Zone of Nigeria.

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ABSTRACT

Background/Objective: Vegetables and fruits are important sources of protective substances, which are highly beneficial for the maintenance of good health and prevention of diseases. Phytochemicals are non-nutritive plant chemicals that have protective or disease preventive properties. The study was designed to determine the phytochemicals, In-vitro-bioavailability of beta carotene and anti-nutrient composition of some neglected underutilized fruits and vegetables in Southeast geopolitical zone of Nigeria.
Methodology: The frequently occurred underutilized fruits and vegetables were selected for the study. The food crops were harvested and identified at the Herbarium in the Department of Plant Science and Biotechnology, University of Nigeria Nsukka. Twenty underutilized fruits and vegetables each were cleaned and analysed for phytochemicals, *In vitro* bioavailability of beta carotene and anti-nutrients composition using standard methods. Data were presented using descriptive statistics, percentage, mean, standard deviation and frequency. **Results:** The result showed that 0 - 40% of beta carotene were bioavailable in the fruits studied. The antinutrient levels in fruits were cyanide (0.02-3.47 mg), oxalate 1.22-12.38 mg and phytate traces- 12.60 mg. The range of phytochemicals in the fruits were tannins trace-10.40 mg, flavonoids 0-0.10 %, saponins trace-0.051 mg, lycopene trace-94.20 mg, and phenol 0-4.01mg. The antinutrient levels in vegetables were cyanide 0.35-13.20 mg, oxalate 2.27-24.69 mg and phytate traces- 2.57 mg. The result showed that 22- 68.80% of beta carotene were bioavailable in the vegetables studied. The phytochemicals in the vegetables were tannins 0.10-10.30 mg, flavonoids trace-0.20 %, saponins trace-0.10 mg, lycopene trace-31.20 mg and phenol 0.01-3.31 mg. **Conclusion:** The use of these neglected fruits and vegetables is imperative because of their nutritional and health benefit.

Keywords: phytochemicals, beta-carotene, neglected, vegetables and fruits.

1. INTRODUCTION

The indigenous knowledge of the health promoting and protecting attributes of vegetables and fruits are clearly linked to their nutritional and non- nutrient bioactive properties. More recent reports have shown that they also contain non- nutrient bioactive phytochemicals that have been linked to protection against cardiovascular and other degenerative diseases. Phytochemicals are non-nutritive plant chemicals that have protective or disease preventive properties (1). Orech, et al. (2) observed that some of these phytochemicals found in some vegetables may pose toxicity problems when consumed in large quantities or over a long period of time.

The inclusion of vegetables in the diets has provided basic nutritional requirements for man and also protection against incidence of chronic, degenerative and age-related disorder diseases, due to the presence of phytochemical and antioxidants (3).

Fruits and vegetables are packed with essential vitamins, minerals and fibre. As a result of this, eating plenty of fruits and vegetables everyday can help reduce risk of heart disease, high blood pressure, type II diabetes and certain cancers. Phytochemicals are usually related to colour, fruits and vegetables of different colours — green, yellow-orange, red, blue-purple, and white — contain their own combination of phytochemicals and nutrients that work together to promote good health. Most phytochemicals have antioxidant activity and protect the cells against oxidative damage and reduce the risk of developing certain types of cancer. Phytochemicals with antioxidant activity include allyl sulfides (onions, leeks, garlic), carotenoids (fruits, carrots), flavonoids (fruits, vegetables), polyphenols (tea, grapes) (1).

Bioavailability of food is defined as the fraction of an ingested nutrient from food that is available for absorption in the intestine and metabolic process and storage (4). Beta-carotene and other carotenoids that can be converted by the body into retinol are referred to as provitamin A carotenoids. Hundreds of different carotenoids are synthesized by plants, but only about 10% of them are provitamin A carotenoids (5).Vitamin A is essential for maintaining normal vision, gene expression, reproduction, embryonic development, growth and immune function (6). Mason (7) reported that there is accumulating evidence that Vitamin A deficiency (VAD) increases risk of developing respiratory diseases and the children who are vitamin A deficient are more likely to suffer from chronic ear infections. Emphasis on prevention of VAD by dietary improvement, fortification and/or supplementation is aimed at ameliorating infectious diseases through effects on immunity and or epithelial tissue (8).

Antinutrients are natural or synthetic compounds that interfere with the absorption of nutrients (9). One common example is phytic acid, which forms insoluble complexes with calcium, zinc, iron and copper (10). Proteins can also be antinutrients, such as the trypsin inhibitor and lectins found in legumes (11). However, polyphenols such as tannins have anticancer properties, so foods such as green tea that contain large amounts of these compounds might be good for the health of some people despite their antinutrient properties (12). Many traditional methods of food preparation such as fermentation, cooking, and malting increase the nutritive quality of plant foods through reducing certain antinutrients such as phytic acid, polyphenols, and oxalic acid (13).

2. MATERIALS AND METHODS

2.1 Study Area/ Study Design

The study was carried out in South East Nigeria.

2.2 Identification of Samples

The plants harvested were identified at the Herbarium in the Department of Botany, University of Nigeria Nsukka, Nigeria. Some samples were randomly selected and used for further study.

2.3 Chemical analysis

3.14 Phytochemical Screening.

A small portion of the extract was subjected to the phytochemical test using Trease and Evans (14) and Harbourne (15) methods to test for alkaloids, flavonoids, saponins, lycopene, phenol and cardiac glycoside. The Folin-Denis Spectrophotometer method was used to determine the tannin content of the foods. The method was described by Pearson (16).

Cyanide was determined by Wang and Filled method (17). Phytate was determined from duplicate samples of food using diluted HCL (18). Oxalate determination was carried out as described by (19).

The method described by Mulokozi et al. (20) was used for the determination of In-vitro bioavailability of B-carotene.

3. RESULTS

Table 1 shows the list of underutilized vegetables selected for analysis.

Table 2 shows the list of underutilized fruits selected for analysis.

Table 3a shows phytochemicals composition of underutilized indigenous vegetables. The flavonoid content of the underutilized vegetables varied from traces to 0.20%/100g on wet weight basis. The vegetable with the highest level (0.10mg/100 g) of saponin was *Vitex doniana* and the ones with the lowest content (traces) of saponin were *Ficus elsticoides* and *Blinghia unijugata.* The vegetable with highest content (10.30mg/100 g) of tannin was *Moraceae spp* while *Ceiba pentandra* had the lowest (0.10 mg/100 g) value of tannins. *Blinghia unijugata* had the highest Lycopene content of 31.20 mg/100 g while *Ficus elsticoides* had traces of

Lycopene. The alkaloid contents of the vegetables varied from 0.10-0.50%/100 g on wet weight basis. The vegetable with the highest level (3.31 mg/100 g) of phenol was *Ficus vogaliana* and the one with the lowest content (0.19 mg/100 g) of phenol was *Portulence oleraceae.* The vegetable with the highest content (6.08 %/100 g) of glycoside was *Ipomea batata* while *Psychotria viridis* had 0.0 %/100 g of glycoside.

Table 3b shows phytochemicals composition of underutilized indigenous fruits. The flavonoid content of the underutilized fruits varied between trace level - 0.10 %/100 g on wet weight basis. The fruit with the highest level (0.051 mg/100 g) of saponin was *Cola gingatean* and the one with traces of saponin were *Napolean imperialist* and *Cola pachycarpa.* The fruit with the highest content (10.40 mg/100 g) of tannin was *Afromomium daniella* while *Cola gigantean* and *parkia clappatonia* had traces of tannins. *Cola pachycarpa* had the highest Lycopene content of 94.20 mg/100 g while *Cola gigantean, Napolean imperialist* and *Hippocretae myrint* had traces of Lycopene. The alkaloid contents of these fruits varied between 0.03 in *Irvingia gabonensis* to 0.80 %/100 g in *Landolfolia dulcis* on wet weight basis. The fruit with the highest level (4.01 mg/100 g) of phenol was *Olax viridis* and the one with traces of phenol was *Hippocretae myrint.* The fruit with the highest content (3.04 %/100 g) of glycoside was *Hippocretae myrint* while *Afromomium daniella and Cola parchycarpa* had traces of glycoside.

Table 4a shows in-vitro bioavailability of beta-carotene in some underutilized vegetables. The bioavailability of beta-carotene for the studied underutilized vegetables ranged from 6.07-942.33 RE/100 g. *Boerhavia diffusa* had the highest bioavailability of beta-carotene while *Ficus elsticoides* had the least value. The percentage availability ranged from 24-68.80 %.

Table 4b shows the *in vitro* bioavailability of beta-carotene of some underutilized fruits. The bioavailability of beta-carotene for the studied underutilized fruits ranged from 4.50-2068.33 RE/100 g. The fruit with the highest bioavailability of beta-carotene (2068.33 RE/100 g) was *Myristicaceae spp* while *Olax viridis* had the least value of 4.50RE/100g. The percentage availability ranged from 21- 40 %.

Table 5a shows the anti-nutrient composition of some underutilized vegetables. The cyanide content of these underutilized vegetables varied between 0.35-13.20 mg/100 g on wet weight basis. The vegetable with the highest level (24.69 mg/100 g) of oxalate was *Ficus elsticoides* and the one with the lowest content (2.27 mg/100 g) of oxalate was *Berlinia grandflora.* The vegetable with the highest level (2.57 mg/100 g) of phytate was *Blinghia unijugata* while *some of the vegetables* had traces of phytate.

Table 5b shows the anti-nutrient composition of some underutilized indigenous fruits. The cyanide content of these underutilized fruits varied between 0.02-3.47 mg/100 g on wet weight basis. The fruit with the highest level (12.38 mg/100 g) of oxalate was *Landolfolia dulcis* and the one with the lowest content (1.22 mg/100 g) of oxalate was *Afromomium daniella. Landolfolia dulcis* had the highest phytate content of 12.60 mg/100 g while majority of the fruits studied had traces of phytate.

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4. DISCUSSION

Phytochemicals

Tannins: Tannin which usually gives rise to a dry, pickery, astringent sensation in the mouth was in the range of 0.10-10.30 % in the vegetables studied. Tannin act as antinutrient when the value is above safe level but below safe level (0.15-0.20 %) it functions as phytochemicals. The range of values obtained for tannins in some of the vegetables were higher than the safe level of tannins (0.15-0.20 %) as recommended by Schiavone et al. (21). *Ficus elasticoides* (0.20 mg), *Ceiba pentandra* (0.10 mg), *Pterocarpus santalinoides* (0.10mg), *Uvaria chamea* (0.20 mg) and *Berlinia grandflora* (0.10 mg) were within the safe level. The range of tannins obtained for the fruits were between traces to 10.40 mg. Fruits such as *Vitex doniana (*0.20 mg*), Parkia clappatonia (*Trace*), Gongronema spp (*0.12 mg*), Sterculiar spp (*0.05 mg*), Myristicaceae spp* (0.10 mg*), Artocarpus altilis* (0.11 mg*)*, and *Cola gingatean* (Trace*)* had tannin levels below the safe level. Consumption of adequate amount of the fruits and vegetables could be useful in prevention and treatment of cancer because of the antioxidant property of tannin. Other fruits with tannin higher than the safe level should be subjected to different food processing methods to reduce the tannin level and extend their food uses. Holz and Gibson (13) suggested that many traditional methods of food preparation such as fermentation, cooking and malting increases the nutritive quality of plant foods through reducing certain anti nutrients such as phytic acid, tannins, polyphenols and oxalic acid. Subjecting the vegetables to these processes will reduce the toxic level and at the same time boast the phytochemical properties of the vegetables (21). Tannins may be employed medically in anti-diarrheal, haemostatic and anti-hemorrhoidal treatment. The anti-inflammatory effects of tannins help to control all indications of gastric enteritis and irritating bowel disorders. Tannins not only heal burns and stop bleeding, but they also stop infection while they continue to heal the wound internally.

Flavonoids: The flavonoid values obtained for the vegetables were between traces to 0.20 %. The values obtained for the fruits were between traces to 0.10 %. Consumption of some vegetables and fruits like *Ipomea batata* leaves (0.20 %) and *Landofolia dulcis* (0.10 %) in significant quantity could be of health benefit due to their flavonoid constituents. Flavonoids lower high blood pressure and have strong anti-inflammatory properties (22). Flavonoids are potent anti-oxidants. They also inhibit low density lipoprotein (LDL) by free radicals and reduce the risk of cancer and Cardiovascular diseases (23). Flavonoids are also involved in platelet aggregation, antimutagenic and antiproliferative properties (24).

Saponin: The saponin contents of the vegetables (traces- 0.10 mg) and fruits (traces-0.10 mg) were appreciably below 3.00mg which was reported by Kumar (25) to be responsible for cattle losses when they grazed on *alfonibrilla*. Saponins have expectorative, anti-inflammatory, and immune stimulating activity. They also demonstrate antimicrobial properties particularly against fungi, bacteria and protozoa (26). There is evidence of the presence of saponins in traditional medicine preparations (27; 28; 29). Saponins are bitter and reduce the palatability of food and increase excretion of cholesterol concentration by free radicals that are bond with cholesterol and other pathogens in the body. Saponin decreases tumor size and improves cognitive ability (30).

Cardiac glycosides: The cardiac glycosides values for the vegetables were traces- 6.08%. The range of cardiac glycoside value obtained for the fruits were between traces to 3.04 %. Consumption of *Daniella olivera* (0.20 %), *Afromomium daniella* (trace), *Cola parchycarpa* (trace), *Ficus vogaliana* (0.64 %), *Ceiba pentandra* (0.60 %) and *Gssampelus mucanta* (0.67 %) should be encouraged because they contain appreciable quantities of cardiac glycosides which could help in the treatment of congestive heart failure and cardiac arrhythmia. Cardiac glycosides may also be used to strengthen a weakened heart and allow it to function more efficiently.

Bioavailability of beta-carotene: The result of the in-vitro bioavailability of beta-carotene in the vegetables and fruits were between 6.07-940.33 RE and 4.50-2068.32 RE, respectively as against 15.20-1933.33 RE and traces to 5666.67 RE, respectively. This represents 22-68.80 %

and traces to 40 % availability respectively. Bioavailability of nutrient is the proportion of the nutrient that when ingested, is absorbed in the body. The remaining amount cannot be metabolized and is removed as waste. Generally, fruits and vegetables are good sources of beta carotene but not all the beta-carotene are absorbed by the body. Adding cooking oil to vegetables while cooking could help in bioavailability of beta carotene. Consumption of 100g of majority of vegetables and fruits as shown in the pictorial record for *Vitex doniana* (580.00), *Ceiba pentandra* (653.33), *Pterocarpus santaloides* (629.00), *Ficus vogaliana* (588.00), *Cola parchycarpa* (2068.32), *Myristicaceae spp* (996.67), *Spondian mombin* (580.00) and *Boerhavia diffusa* (940.33) could provide the RNI (400 RE) for provitamin A (31). Beta-carotene serves as powerful antioxidant, fights against heart diseases, improves absorption of iron, prevents iron deficiency anemia, reduces the risk of cancer (lung and stomach), protects skin from sun damage, promotes eye health, protects against cancer, stroke and high blood pressure (32).

Antinutrients.

Phytate: The range of phytate values (trace-2.57 mg) for all the vegetables studied were below the toxic limit for phytate (5.00 mg/100 g) (33). The low level of phytate in the vegetables studied suggests that phytic acid concentration in the vegetables studied may not chelate important minerals such as calcium, magnesium, iron and zinc in the diet containing the vegetables (34). The diet will however protect the body against cancer because of its phytochemical properties (35). The range of phytate values for all the fruits studied were (trace-12.06 mg). *Landolfolia dulcis* (12.60 mg), *Phyllanthus debilis* (10.18 mg) and *Gongronema spp* (8.20 mg) had high levels. It may be necessary to reduce the antinutrient content of the fruits, since most fruits are eaten raw.

Oxalate: The oxalate values for all the vegetables studied were within the range 2.27-24.69 mg. The values obtained in this study were higher than the toxic limit for oxalate (2.20 mg) (26). Holz and Gibson (13) suggested that many traditional methods of food preparation such as fermentation, cooking and malting increases the nutritive quality of plant foods through reducing certain anti nutrients such as phytic acid, polyphenols and oxalic acid. The result of the fruits studied showed 1.22-12.38 mg/100 g of oxalate. Majority of the fruits had oxalate level higher than the toxic limit while fruits such as *Phyllanthus debilis* (1.88 mg), *Irvingia gabonensis* (1.44 mg), *Afromomium daniella* (1.22 mg) *Hippocretae myrint* (1.89 mg), *Icacina trichatha olive*

(2.01 mg) and *Napoleana imperialist* (1.37 mg) had oxalate levels lower than toxic limit. Since most fruits are eaten raw, the high oxalate level of some of the fruits may pose a problem when the fruits are consumed raw. The fruits could be processed into fruit juice or drink to reduce the oxalate level to acceptable level thereby extending the food uses of the fruits.

Toxicant

Cyanide: The cyanide levels (0.35-13.20 mg) and (0.02-3.47 mg) in the vegetables and fruits were below the toxic limit for cyanide (35 mg) (33). Cyanide is a toxin affecting the host when consumed in large quantity. The low levels of cyanide in the vegetables and fruits studied suggest that cyanide content of these vegetable may not pose a threat to the consumers.

Table 1: List of underutilized vegetables randomly selected for analysis.

Common name	Igbo name	Scientific name
Vegetable		
Fig tree	*Ogbu ike*	*Ficus elasticoides*
Hog weed	*Azuigwe*	*Boerhavia diffusa*
-	*Ogbu*	*Ficus vogaliana*
Black plum	*Uchakiri*	*Vitex doniana*
-	*Uturukpa*	*Pterocarpus santalinoides*
_	*Anyazu*	*psychotria viridis*
Water leaf	*Ntioke*	*Portulace oleraceae*
-	*Agba*	*Daniella olivera*
Jute	*Arira/Elegule*	*Corchorus olitorius*
-	*Akwokwo akpu*	*Ceiba pentandra*
__	*Okwuruezikemba*	*Moraceae spp*
_	*Ogwuazu*	*Bombaceae spp*
_	*Okpokuko*	*Uvaria chamea*
_	*Akuokoro*	*Ficus fur*
_	*Ububa*	*Berlinia grandflora*
Akee/Ackee	*Uso*	*Blighia unijugata*
Huckleberry	*Ewa*	*Vaccinium parvifolium*
_	*Obuako-enwe*	*Gssampelus mucanta*
_	*Agbolu-uku*	*Brillantaisi nitens*
Potato leaves	*Akwukwo ji nnu*	*Ipomea batata*

Table 2: List of fruits randomly selected for analysis.

Common name Fruits	Igbo name	Scientific name
Hog plum	*Echikara*	*Spondian mombin*
Black plum	*Mbembe*	*Vitex doniana*
-	*Icheku*	*Velvet tamarind*
-	*Osisiike/Karagu*	*Myristicaceae spp*
_	*Urumbia*	*Icacina trichatha olive*
_	*Mkpuruamunwaebule*	*Hippocretae myrint*
_	*Aku okoro*	*Ficus sur*
_	*Ose ohia*	*Afromomium daniella*
_	*Uvuru*	*Nauclea diderrichii*
_	*Uvurunwamkpi*	Artocarpus altilis
White rubber vine	*Utu*	*Landolfolia dulcis*
West African locust bean	*Nkpuru ugba*	*Parkia clappatonia*
_	*Achicha*	*Cola parchycarpa*
Bush mango	*Ujuru*	*Irvingia gabonensis*
_	*Oji-eyi*	*Cola gingatean*
_	*Osenga*	*Olax viridis*
_	*Aodo*	*Gongronema spp*
Gooseberry	*Akpuru*	*Phyllanthus debilis*
_	*Nkwukpo*	*Sterculiar spp*
_	*Odure*	*Napoleana imperialist*

Table 3a: Phytochemicals composition of some underutilized vegetables on wet weight basis.

Scientific name	Flavonoids (%)	Saponins (mg)	Lycopenes (mg)	Alkaloids (mg)	Tannins (mg)	Phenols (mg)	Glycosides (%)
V. doniana	**Trace**	**0.100±0.25**	10.40±0.03	0.20±0.06	6.30±0.72	2.80±0.03	0.71±0.65
F. elsticoides	0.001±0.40	Trace	Trace	0.61 ±0.00	0.20±0.12	0.19±0.26	1.60±0.12
F. vogaliana	0.031±0.18	0.002±0.01	8.80±0.11	0.11±0.13	3.20±1.24	**3.31±0.18**	0.64±0.23
C. pentandra	0.011±1.21	0.003±0.01	26.10±0.01	0.24±0.17	**0.10±0.14**	1.10±0.33	0.60±0.41
P.oleraceae	0.001±0.35	Trace	Trace	0.10±0.06	2.49±1.00	**0.01±0.11**	1.00±0.09
D. olivera	Trace	0.030±0.29	10.10±0.04	0.30±0.24	3.10±0.23	1.03±0.32	0.20±0.06
P. santalinoides	0.090±0.08	0.010±0.01	10.70±0.13	0.121±1.02	**0.10±0.01**	0.57±1.27	1.62±0.84
p. viridis	0.009± 0.64	0.080±0.04	13.00±0.01	0.47±0.18	1.30±0.35	3.20±1.12	Trace
H.crinite	0.010±0.11	0.013±0.72	2.40±0.12	0.40±0.02	2.04±0.47	3.01±0.14	1.24±0.17
Moraceae spp	Trace	0.005±0.25	1.24±0.03	0.15±0.06	**10.30±0.72**	0.93±0.55	1.80±0.10
Bombaceae spp	0.003±0.40	0.047±0.00	3.20±0.2	0.40±0.34	3.10±0.12	1.16±0.26	3.25±0.92
U. chamea	0.010 ±0.22	0.024±0.00	9.10±0.01	0.32±0.32	0.20±0.09	2.40±1.08	4.98±0.72
Ficus sur	0.051±0.18	0.011±0.01	12.70±0.14	0.43±0.03	0.43±0.03	1.55±0.64	1.25±0.83
B. grandflora	0.030 ±1.21	0.006±0.01	4.70±0.01	0.27±0.91	**0.10±0.14**	1.26±0.01	5.57±0.88
B. unijugata	0.060±0.35	0.0	**31.20±0.06**	**0.50±0.01**	4.68±1.00	3.00±0.02	2.67±0.16
B. nitens	0.020±0.29	0.010±0.04	6.10±0.24	0.47±0.22	0.30±0.23	1.20±0.07	3.36±0.18
G. mucanta	0.040± 0.64	0.031±0.04	3.10±0.01	0.33±1.23	2.61±0.35	2.40±0.36	0.67±0.29
I.batata	**0.200± 0.72**	0.001±0.12	1.13±0.02	0.27±0.65	7.43±0.47	1.80±0.13	**6.08±0.49**

Mean ± Standard deviation

Table 3b: Phytochemical composition of some underutilized fruits on wet weight basis.

Scientific name	Flavonoids (%)	Saponin (mg)	Lycopene (mg)	Alkaloids (mg)	Tannins (mg)	Phenols (mg)	Glycoside (%)
H. myrint	Trace	0.021±0.90	Trace	0.57±0.01	1.50±0.25	0.07±0.16	**3.04±0.92**
N. diderrichii	0.001±0.92	0.030±0.06	1.20±0.24	0.26±0.12	1.30±0.17	2.34±0.59	1.34±0.02
I. trichatha olive	0.005 ±0.87	0.020± 0.02	0.10±1.06	0.10±0.16	1.40±0.79	1.21±0.28	1.90±0.74
N. imperialist	0.010± 0.59	Trace	Trace	0.20±0.01	1.20±0.06	0.23±0.22	2.10±0.25
A. daniella	0.030±0.74	0.001± 0.43	8.30±1.08	0.43±0.01	**10.40±0.08**	3.22±0.08	Trace
V.tamarind	0.020±0.06	0.004±0.09	11.80±0.22	0.51±1.23	1.40±1.08	2.13±0.09	0.22±0.07
Myristicaceae spp	0.010±0.01	0.031±0.28	5.00±0.09	0.23±1.45	0.10±0.07	2.74±0.03	3.11±0.18
Olax viridis	0.001± 0.02	0.009±0.07	2.10±0.47	0.40±0.22	1.30±0.04	**4.01±0.09**	1.24±0.23
A. altilis	0.030±0.25	0.011±0.03	22.40±0.06	0.27±0.98	0.11±0.72	1.10±0.12	1.40±0.21
C. gingatean	Trace	**0.051±0.29**	Trace	0.54±0.04	Trace	4.00±0.11	2.10±0.60
Ficus sur	0.002 ±0.08	0.036±0.01	4.40±0.13	0.20±0.52	0.12±0.01	Trace	0.96±0.88
P. debilis	0.003 ± 0.64	0.010±0.04	27.04±0.01	0.14±0.0	2.41±0.35	0.87±0.26	2.41±0.15
Sterculiar spp	0.050± 0.72	0.031±0.12	18.16±0.02	0.30±0.12	0.05±0.47	2.41±0.18	2.40±0.10
L. dulcis	**0.100 ±0.40**	0.030±0.00	1.80±0.06	**0.80±0.76**	3.40±0.12	1.96±0.00	1.92±0.11
C. parchycarpa	0.070±0.18	Trace	**94.20±0.01**	0.30±2.01	1.30±1.24	3.26±0.24	Trace
Gongronema spp	0.004 ±1.21	0.043±0.01	7.00±0.01	0.60±0.17	0.12±0.14	2.01±0.59	0.11±0.01
S.mombi	0.040± 0.43	0.031±0.03	3.10± 0.21	0.32± 0.10	0.40± 0.13	3.30± 0.00	0.48± 0.08
V.doniana	0.020± 0.01	0.004± 0.28	11.80±0.16	0.51± 0.06	0.20± 0.17	3.93± 0.23	3.03± 0.12
P.clappatoniana	Trace	0.001± 0.11	50.20±1.12	0.36± 0.98	Trace	1.04± 0.54	0.06± 0.18
I.gabonensis	0.050± 0.72	0.031± 0.13	18.16±0.22	**0.03± 1.15**	1.55± 0.64	2.24± 0.33	1.22± 1.52

Mean±Standard deviation

Table 4a: In-vitro Bioavailability of Beta- carotene in some underutilized vegetables

Scientific name	B- carotene (RE) as Determined	B-carotene (RE) available	(%) Availability
Vitex doniana	**1933.33±21.59**	580.00	30
Ficus elsticoides	**15.20±0.29**	**6.07**	40
Corchorus olitorius	16.00±0.35	6.24	39
Ficus vogaliana	1633.33±8.74	588.00	36
Ceiba pentandra	1866.67±18.17	653.33	35
Portulace oleraceae	31.20±0.14	12.23	39
Daniella olivera	22.40±0.11	8.74	39
Pterocarpus santalinoides	1233.33±6.18	629.00	51
Uvaria chamea	200.00±0.35	56.00	28
Ficus sur	356.67±2.74	217.33	22
Berlinia grandflora	356.67±1.17	117.00	33
Blinghia unijugata	591.67±1.14	142.00	24
Brillantaisi nitens	700.00±0.11	259.00	37
Vaccinium parvifolium	451.67±2.18	176.15	39
Gssampelus mucanta	266.83±0.01	72.58	27.20
Ipomea batata	701.67± 0.19	213.66	30.45
psychotria viridis	25.67±0.01	10.13	39.40
Boerhavia diffusa	1366.67± 0.19	**940.33**	68.80
Moraceae spp	450.00±0.59	130.50	29
Bombaceae spp	6161.67±1.29	565.83	35

Mean and percentage bio-accessible.

Table 4b: In-vitro Bioavailability of Beta- carotene in some underutilized fruits.

Scientific name	B-carotene (RE) as determined	B-carotene (RE) available	(%) Availability
Hippocretae myrint	Trace	—	—
Nauclea diderrichii	1233.33±6.62	394.67	32
Icacina trichatha olive	16.67±0.94	6.67	40
Napoleana imperialist	Trace	—	—
Spondian mombin	2000.00±9.71	580.00	29
Vitex doniana	1333.33±0.76	392.00	29.41
Afromomium daniella	566.67±0.73	170.00	30
Vevet tamarind	Trace	—	—
Myristicaceae spp	4333.33±11.03	996.67	23
Olax viridis	16.67± 0.09	**4.50**	27
Irvingia gabonensis	416.67±2.14	132.32	32
Cola gingatean	46.67±0.11	9.33	20
Ficus sur	665.00±1.18	259.33	39
Phyllanthus debilis	141.67±0.01	35.42	25
Sterculiar spp	60.00± 0.19	12.60	21
Artocarpus altilis	199.83±4.59	51.96	26
Landfolia dulcis	48.33±0.29	11.12	23
Parkia clappatonia	970.67±1.35	371.57	38.28
Cola parchycarpa	**5666.67±2.74**	**2068.32**	36.5
Gongronema spp	17.5±0.17	5.25	30

Mean and percentage bio-accessible

Table 5a: Antinutrient composition of some underutilized vegetables on wet weight basis (mg/100g).

Scientific name	Cyanide	Oxalate	Phytate
Vitex doniana	12.14±0.25	10.02±0.03	1.90±0.06
Ficus elsticoides	11.59±0.40	**24.69±0.00**	1.40±0.06
Corchorus olitorius	3.24 ±0.22	9.21 ±0.00	0.30±0.01
Ficus vogaliana	4.71±0.18	13.02±0.01	Trace
Ceiba pentandra	**13.20±1.21**	11.97±0.01	1.20±0.01
Portulace oleraceae	3.91±0.35	14.16±0.06	0.40±0.01
Daniella olivera	5.20±0.29	23.12±0.04	1.54±0.24
Pterocarpus santalinoides	6.23 ±0.08	17.02±0.01	1.10±0.13
psychotria viridis	2.14 ± 0.64	3.24±0.04	1.07±0.01
Boerhavia diffusa	4.47± 0.72	4.96±0.12	1.24±0.02
Moraceae spp	0.67±0.25	2.70±0.03	2.30±0.06
Bombaceae spp	0.57 ±0.40	2.38±0.00	Trace
Uvaria chamea	0.47 ±0.22	5.91±0.00	Trace
Ficus sur	2.04±0.18	4.28±0.01	Trace
Berlinia grandflora	0.52 ±1.21	**2.27±0.01**	1.10±0.01
Blinghia unijugata	**0.35±0.35**	4.56±0.06	**2.57±0.01**
Brillantaisi nitens	0.45±0.29	3.78±0.04	1.90±0.24
Vaccinium parvifolium	1.94 ±0.08	3.87±0.01	10.01±0.13
Gssampelus mucanta	0.45 ± 0.64	3.52±0.04	2.34±0.01
Ipomea batata	0.98± 0.72	2.84±0.12	0.82±0.02

Mean ± Standard deviation

Table 5b: Anti-nutrient composition of some underutilized fruits on wet weight basis (mg/100g).

Scientific name	Cyanide	Oxalate	Phytate
Hippocretae myrint	1.07±0.90	1.89±0.01	Trace
Nauclea diderrichii	0.82 ±0.92	3.10 ± 0.06	Trace
Icacina trichatha olive	1.20 ±0.87	2.01± 0.02	Trace
Napoleana imperialist	3.24± 0.59	1.37±0.01	Trace
Spondian mombin	2.71±0.02	4.30±0.03	1.20±0.25
Vitex doniana	3.01±0.19	2.26±0.04	2.88±0.28
Afromomium daniella	1.77±0.74	**1.22± 0.43**	3.40±1.08
Vevet tamarind	1.53±0.06	2.77±0.09	Trace
Myristicaceae spp	2.20±0.01	3.08 ±0.28	Trace
Olax viridis	1.24± 0.02	4.03± 0.07	Trace
Artocarpus altilis	0.30±0.25	12.08±0.03	4.02±0.06
Irvingia gabonensis	2.23±0.35	1.44±0.06	1.64±0.01
Cola gingatean	1.22±0.29	3.87±0.04	1.10±0.24
Ficus sur	0.05 ±0.08	12.02±0.01	10.18±0.13
Phyllanthus debilis	**3.47 ± 0.64**	1.88±0.04	0.21±0.01
Sterculiar spp	0.14± 0.72	6.16±0.12	5.15±0.02
Landolfolia dulcis	0.27 ±0.40	**12.38±0.00**	**12.60±0.06**
Parkia clappatonia	0.34 ±0.22	9.02 ±0.00	1.20±0.01
Cola parchycarpa	1.98±0.18	7.11±0.01	2.72±2.01
Gongronema spp	**0.02 ±1.21**	12.22±0.01	8.20±0.01

Mean±Standard deviation

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