

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

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5 **N. N. Umerah^{1*} and N. M. Nnam²**

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7 ¹*Department of Food Science and Technology, Enugu State University of Science and Technology,*
8 *Nigeria.*

9 ²*Department of Home Science, Nutrition and Dietetics, University of Nigeria, Nsukka, Nigeria.*

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13 **ABSTRACT**
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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 health benefit.

15
16 *Keywords: phytochemicals, beta-carotene, neglected, vegetables and fruits.*
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18 **1. INTRODUCTION**

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

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

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

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

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

58 2. MATERIALS AND METHODS

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60 2.1 Study Area/ Study Design

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62 The study was carried out in South East Nigeria.

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64 2.2 Identification of Samples

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

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69 2.3 Chemical analysis

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3.14 Phytochemical Screening.

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

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

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

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81 3. RESULTS

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

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

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

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

96 Table 3b shows phytochemicals composition of underutilized indigenous fruits. The flavonoid
97 content of the underutilized fruits varied between trace level - 0.10 %/100 g on wet weight basis.
98 The fruit with the highest level (0.051 mg/100 g) of saponin was *Cola gingatean* and the one
99 with traces of saponin were *Napolean imperialist* and *Cola pachycarpa*. The fruit with the
100 highest content (10.40 mg/100 g) of tannin was *Afromomium daniella* while *Cola gigantean* and
101 *parkia clappatonia* had traces of tannins. *Cola pachycarpa* had the highest Lycopene content of
102 94.20 mg/100 g while *Cola gigantean*, *Napolean imperialist* and *Hippocretae myrint* had traces
103 of Lycopene. The alkaloid contents of these fruits varied between 0.03 in *Irvingia gabonensis* to
104 0.80 %/100 g in *Landolfolia dulcis* on wet weight basis. The fruit with the highest level (4.01
105 mg/100 g) of phenol was *Olox viridis* and the one with traces of phenol was *Hippocretae myrint*.
106 The fruit with the highest content (3.04 %/100 g) of glycoside was *Hippocretae myrint* while
107 *Afromomium daniella* and *Cola parchycarpa* had traces of glycoside.

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

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

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

121 vegetable with the highest level (2.57 mg/100 g) of phytate was *Blinghia unijugata* while some
122 of the vegetables had traces of phytate.

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

129 4. DISCUSSION

130 Phytochemicals

131 **Tannins:** Tannin which usually gives rise to a dry, pickery, astringent sensation in the mouth
132 was in the range of 0.10-10.30 % in the vegetables studied. Tannin act as antinutrient when the
133 value is above safe level but below safe level (0.15-0.20 %) it functions as phytochemicals. The
134 range of values obtained for tannins in some of the vegetables were higher than the safe level of
135 tannins (0.15-0.20 %) as recommended by Schiavone et al. (21). *Ficus elasticoides* (0.20 mg),
136 *Ceiba pentandra* (0.10 mg), *Pterocarpus santalinoides* (0.10mg), *Uvaria chamea* (0.20 mg) and
137 *Berlinia grandiflora* (0.10 mg) were within the safe level. The range of tannins obtained for the
138 fruits were between traces to 10.40 mg. Fruits such as *Vitex doniana* (0.20 mg), *Parkia*
139 *clappatonia* (Trace), *Gongronema spp* (0.12 mg), *Sterculiar spp* (0.05 mg), *Myristicaceae spp*
140 (0.10 mg), *Artocarpus altilis* (0.11 mg), and *Cola gingatean* (Trace) had tannin levels below the
141 safe level. Consumption of adequate amount of the fruits and vegetables could be useful in
142 prevention and treatment of cancer because of the antioxidant property of tannin. Other fruits
143 with tannin higher than the safe level should be subjected to different food processing methods to
144 reduce the tannin level and extend their food uses. Holz and Gibson (13) suggested that many
145 traditional methods of food preparation such as fermentation, cooking and malting increases the
146 nutritive quality of plant foods through reducing certain anti nutrients such as phytic acid,
147 tannins, polyphenols and oxalic acid. Subjecting the vegetables to these processes will reduce
148 the toxic level and at the same time boast the phytochemical properties of the vegetables (21).
149 Tannins may be employed medically in anti-diarrheal, hemostatic and anti-hemorrhoidal
150 treatment. The anti inflammatory effects of tannins help to control all indications of gastric

151 enteritis and irritating bowel disorders. Tannins not only heal burns and stop bleeding, but they
152 also stop infection while they continue to heal the wound internally.

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

161 **Saponin:** The saponin contents of the vegetables (traces- 0.10 mg) and fruits (traces-0.10 mg)
162 were appreciably below 3.00mg which was reported by Kumar (25) to be responsible for cattle
163 losses when they grazed on *alfonibrilla*. Saponins have expectorative, anti-inflammatory, and
164 immune stimulating activity. They also demonstrate antimicrobial properties particularly against
165 fungi, bacteria and protozoa (26). There is evidence of the presence of saponins in traditional
166 medicine preparations (27; 28; 29). Saponins are bitter and reduce the palatability of food and
167 increase excretion of cholesterol concentration by free radicals that are bond with cholesterol
168 and other pathogens in the body. Saponin decreases tumor size and improves cognitive ability
169 (30).

170 **Cardiac glycosides:** The cardiac glycosides values for the vegetables were traces- 6.08%. The
171 range of cardiac glycoside value obtained for the fruits were between traces to 3.04 %.
172 Consumption of *Daniella olivera* (0.20 %), *Afromomium daniella* (trace), *Cola parchycarpa*
173 (trace), *Ficus vogaliana* (0.64 %), *Ceiba pentandra* (0.60 %) and *Gssampelus mucanta* (0.67
174 %) should be encouraged because they contain appreciable quantities of cardiac glycosides
175 which could help in the treatment of congestive heart failure and cardiac arrhythmia. Cardiac
176 glycosides may also be used to strengthen a weakened heart and allow it to function more
177 efficiently.

178 **Bioavailability of beta-carotene:** The result of the in-vitro bioavailability of beta-carotene in
179 the vegetables and fruits were between 6.07-940.33 RE and 4.50-2068.32 RE, respectively as

180 against 15.20-1933.33 RE and traces to 5666.67 RE, respectively. This represents 22-68.80 %
181 and traces to 40 % availability respectively. Bioavailability of nutrient is the proportion of the
182 nutrient that when ingested, actually is absorbed in the body. The remaining amount cannot be
183 metabolized and is removed as waste. Generally, fruits and vegetables are good sources of beta
184 carotene but not all the beta-carotene are absorbed by the body. Adding cooking oil to vegetables
185 while cooking could help in bioavailability of beta carotene. Consumption of 100g of majority
186 of vegetables and fruits as shown in the pictorial record for *Vitex doniana* (580.00), *Ceiba*
187 *pentandra* (653.33), *Pterocarpus santaloides* (629.00), *Ficus vogaliana* (588.00), *Cola*
188 *parchycarpa* (2068.32), *Myristicaceae spp* (996.67), *Spondian mombin* (580.00) and *Boerhavia*
189 *diffusa* (940.33) could provide the RNI (400 RE) for provitamin A (31). Beta-carotene serves as
190 powerful antioxidant, fights against heart diseases, improves absorption of iron, prevents iron
191 deficiency anemia, reduces the risk of cancer (lung and stomach), protects skin from sun
192 damage, promotes eye health, protects against cancer, stroke and high blood pressure (32).

193 **Antinutrients.**

194 **Phytate :** The range of phytate values (trace-2.57 mg) for all the vegetables studied were below
195 the toxic limit for phytate (5.00 mg/100 g) (33). The low level of phytate in the vegetables
196 studied suggests that phytic acid concentration in the vegetables studied may not chelate
197 important minerals such as calcium, magnesium, iron and zinc in the diet containing the
198 vegetables (34). The diet will however protect the body against cancer because of its
199 phytochemical properties (35). The range of phytate values for all the fruits studied were (trace-
200 12.06 mg). *Landolfolia dulcis* (12.60 mg), *Phyllanthus debilis* (10.18 mg) and *Gongronema spp*
201 (8.20 mg) had high levels. There may be need to reduce the antinutrient content of the fruits,
202 since most fruits are eaten raw.

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

210 mg), *Aframomium daniella* (1.22 mg) *Hippocretae myrint* (1.89 mg), *Icacina trichatha olive*
211 (2.01 mg) and *Napoleana imperialist* (1.37 mg) had oxalate levels lower than toxic limit. Since
212 most fruits are eaten raw, the high oxalate level of some of the fruits may pose a problem when
213 the fruits are consumed raw. The fruits could be processed into fruit juice or drink to reduce the
214 oxalate level to acceptable level thereby extending the food uses of the fruits.

215 **Toxicant**

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

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

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

239 **Table 2: List of fruits randomly selected for analysis.**

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

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

Scientific name	Flavonoids (%)	Saponins (mg)	Lycopenes (mg)	Alkaloids (mg)	Tannins (mg)	Phenols (mg)	Glycosides (%)
<i>V. doniana</i>	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
<i>F. elsticoides</i>	0.001±0.40	Trace	Trace	0.61 ±0.00	0.20±0.12	0.19±0.26	1.60±0.12
<i>F. vogaliana</i>	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
<i>C. pentandra</i>	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
<i>P.oleraceae</i>	0.001±0.35	Trace	Trace	0.10±0.06	2.49±1.00	0.01±0.11	1.00±0.09
<i>D. olivera</i>	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
<i>P. santalinoides</i>	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
<i>p. viridis</i>	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
<i>H.crinite</i>	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
<i>Moraceae spp</i>	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
<i>Bombaceae spp</i>	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
<i>U. chamea</i>	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
<i>Ficus sur</i>	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
<i>B. grandflora</i>	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
<i>B. unijugata</i>	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
<i>B. nitens</i>	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
<i>G. mucanta</i>	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>I.batata</i>	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

243 Mean ± Standard deviation

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254 **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 (%)
<i>H. myrint</i>	Trace	0.021±0.90	Trace	0.57±0.01	1.50±0.25	0.07±0.16	3.04±0.92
<i>N. diderrichii</i>	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>I. trichatha olive</i>	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
<i>N. imperialist</i>	0.010± 0.59	Trace	Trace	0.20±0.01	1.20±0.06	0.23±0.22	2.10±0.25
<i>A. daniella</i>	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
<i>V.tamarind</i>	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
<i>Myristicaceae spp</i>	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
<i>Olax viridis</i>	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
<i>A. altilis</i>	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
<i>C. gingatean</i>	Trace	0.051±0.29	Trace	0.54±0.04	Trace	4.00±0.11	2.10±0.60
<i>Ficus sur</i>	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
<i>P. debilis</i>	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
<i>Sterculiar spp</i>	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
<i>L. dulcis</i>	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
<i>C. parchycarpa</i>	0.070±0.18	Trace	94.20±0.01	0.30±2.01	1.30±1.24	3.26±0.24	Trace
<i>Gongronema spp</i>	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
<i>S.mombi</i>	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
<i>V.doniana</i>	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
<i>P.clappatoniana</i>	Trace	0.001± 0.11	50.20±1.12	0.36± 0.98	Trace	1.04± 0.54	0.06± 0.18
<i>I.gabonensis</i>	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

255 Mean±Standard deviation

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

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

269 Mean and percentage bio-accessible.

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

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

277 Mean and percentage bio-accessible

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

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

284 Mean ± Standard deviation

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

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

301 Mean±Standard deviation

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