

Nutritional implication of Neglected Underutilized Green Leafy Vegetables and Fruits in South East Geopolitical Zone of Nigeria

ABSTRACT

Background/Objective: Vegetables and fruits play a highly significant role in food security of the underprivileged in both urban and rural settings. Fruits and vegetables have been implicated for curbing several diet related diseases like anaemia, goiter, obesity, diabetes mellitus, hypertension, cancer and cardiovascular diseases. The study was designed to determine the nutritional implication 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 nutrients composition using standard methods. Data were presented using descriptive statistics, percentage, mean, standard deviation and frequency. **Results:** The proximate composition of the fruits ranged from moisture 54.34-80.30 %, protein 0.27-6.21 %, fat 0-3.08 %, fibre 0.28-8.58 %, ash 0.33-11.05 % and carbohydrate 9.08-36.61 %. The ranges for mineral values of the fruits were iron 0.10-9.60 mg, zinc 0.02-10.30 mg, manganese 0.10-6.60 mg and calcium 5.42-46.50 mg. The vitamin contents of the fruits ranged from beta-carotene traces -5666.67 RE, ascorbic acid 0-48.82 mg and vitamin E 0 -11.99 mg. The proximate composition of the vegetables ranged from moisture 60.45-91.00%, protein 0.02-6.60%, fat 0.02-2.19 %, fibre 0.04-5.01 %, ash 0.04-4.20 % and carbohydrate 10.30-36.61 %. The ranges for mineral values of the vegetables were iron 1.40-14.80 mg, zinc trace-9.40 mg, manganese 0.07-4.80 mg and calcium 18.19-400.00 mg. The vitamin levels of the vegetables were beta-carotene 15.20-1933.33 RE, ascorbic acid 2.40-38.40 mg and vitamin E traces - 6.67 mg. **Conclusion:** The use of these fruits and vegetables should be popularized and extended to areas where they are not produced through nutrition education in order to extend the food use of these crops.

Keywords: Nutritional, implication, underutilized; vegetables and fruits.

1. INTRODUCTION

United Nations Food and Agriculture Organization (1) has widely noted that most widespread and debilitating nutritional disorders, like birth defects, mental and physical retardation, weakened immune systems, blindness and even death has resulted from poor fruits and vegetables consumption habits (2). The ideal strategy to fighting micronutrient deficiency is to improve the diet by including a large variety of food rich in micronutrients and to increase dietary absorption of these nutrients. According to Okigbo (3) while the crisis situation caused by lack of animal foods may require broad and fundamental rethinking about policy and action, traditional food may be the short term remedy. Micronutrients are found in vegetables and fruits but in a form less easily absorbed unless taken at the same time with enhancer or processed in a way to enhance the absorption of these micronutrients (4). Quite large number of indigenous leafy vegetables and fruits have long been known and reported to have health protecting properties

22 and uses. Vegetables and fruits are important sources of protective substances, which are
23 highly beneficial for the maintenance of good health and prevention of diseases (5; 6). The
24 inclusion of vegetables and fruits in the diets has provided basic nutritional requirements for
25 man and also protection. The indigenous knowledge of the health promoting and protecting
26 attributes of vegetables and fruits are clearly linked to their nutritional and non- nutrient bioactive
27 properties. Indigenous fruits and vegetables have long been, and continue to be reported to
28 significantly contribute to the dietary vitamin and mineral intakes of local populations (7). The
29 potassium content of leafy vegetables and fruits are good in the control of diuretic and
30 hypertensive complications, because it lowers arterial blood pressure. The fiber content also
31 contribute to the feeling of satisfaction and prevents constipation (8). In spite of the body of
32 evidence confirming the nutritional contribution of indigenous vegetables and fruits to local diets,
33 their health maintenance and protective properties, there has been very little concerted effort
34 towards exploiting the biodiverse nutritional and health properties of fruits and vegetables to
35 address the complex food, nutrition and health problems of the society. The ultimate goal of the
36 research was to analyse the chemical composition of these underutilized fruits and vegetables
37 which will enhance better food selection and consequently improve the nutritional status of both
38 the rural and urban dwellers.

39 **2. MATERIALS AND METHODS**

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41 **2.1 Study Area/ Study Design**

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43 The study was carried out in South East Nigeria. The study design used was experimental study.

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45 **2.2 Identification of Samples**

46

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

49

50 **2.3 Chemical analysis**

51 Proximate (protein, carbohydrate, fat, moisture, fibre and ash), some minerals and vitamins of
52 both underutilized vegetables and fruits were determined in triplicate using standard method.

53

54 **3. RESULTS**

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

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

57 **Table 1a shows** the proximate composition of twenty underutilized indigenous vegetables. The
58 moisture content of these indigenous vegetables ranged from 60.45-91.00% per 100g edible
59 portion, with *Bombaceae spp* having the highest moisture content and *Blinghia unijugata* having
60 the least value. The protein content varied from 0.02-6.60% per 100g sample with *Ficus*

61 *elsticoides* having the highest protein content. The fat content of the samples ranged from 0.02 in
62 *Moraceae spp* to 2.19% in *Vaccinium parvifolium* per 100g sample. The crude fibre contents of
63 the samples ranged from 0.04-5.01%/100g, with *Bombaceae spp* having the highest crude fibre
64 content. The ash content of the vegetables were between 0.04 in *Euphobiaceae spp* to 4.20% in
65 *Pterocarpus santalinoides* while the carbohydrate content of the samples were between 10.30-
66 30.49%.

67 **Table 1b shows** the proximate composition of some underutilized fruits. The moisture content of
68 these underutilized fruits ranged from 54.34-80.30%, with *Phyllanthus debilis* having the highest
69 moisture value and *Parkia clappatonia* having the least value. The protein content varied from
70 0.27-6.21% with *Irvingia gabonensis* fruits having the highest protein content. The fat content of
71 the samples ranged from Traces-3.08%. The crude fibre contents of the samples ranged from
72 0.11-8.58%/100g, with *Ficus sur* having the highest crude fibre value. The ash content of the
73 fruits were between 0.33-11.05%/100g sample while the carbohydrate contents of the samples
74 were between 9.08-36.61%. All values are on wet weight basis.

75 **Table 2a** shows the mineral composition of the twenty underutilized vegetables. The iron content
76 of the underutilized vegetables were between 1.40-11.80mg/100g with *psychotria viridis* having
77 the highest iron content and *Bombaceae spp* and *Blinghia nitens* having the least value. The
78 copper content was highest in *Ipomea batata* (3.14mg/100g) and lowest in *Moraceae spp*
79 (0.02mg/100g). The levels for other minerals are zinc (0.00-9.40mg/100g), manganese (0.07-
80 4.80mg/100g), calcium (18.19-400.00mg/100g), magnesium (4.38-47.20mg/100g), sodium
81 (0.27-3.01mg/100g), potassium (16.20-104.23mg/100g), and phosphorus (75.40-
82 685.60mg/100g).

83 **Table 2b** shows the mineral composition of some underutilized indigenous fruits. The iron
84 contents of these underutilized fruits were between 0.10-9.80mg/100g with *Vevet tamarind*
85 having the highest iron content and *Gongronema spp* having the least value. The copper content
86 was highest in *Gongronema spp* (4.06mg/100g) and lowest in *Olox viridis* (0.00mg/100g). The
87 levels for other minerals are zinc (0.02-10.30mg/100g), manganese (0.10-6.60mg/100g), calcium
88 (5.42-46.50mg/100g), magnesium (0.21-31.82mg/100g), sodium (Trace-6.20mg/100g),
89 potassium (2.43-410.00mg/100g), and phosphorus (1.70-44.66mg/100g).

90 **Table 3a shows** the B-carotene and vitamin composition of some underutilized vegetables. The
91 beta carotene contents of the underutilized vegetables were between 15.20-1933.33 RE/100g
92 sample with *Vitex doniana* having the highest beta carotene value. The ascorbic acid contents
93 varied between 2.40-38.40mg /100g sample while the vitamin E contents were from Traces-
94 6.67mg/100g sample.

95 **Table 3b shows** the B-carotene and vitamin composition of some underutilized fruits. The beta-
96 carotene content of the underutilized fruits ranges from traces of beta-carotene to 5666.67RE
97 /100g sample with *Cola parchycarpa* having the highest beta-carotene value. The ascorbic acid
98 contents varied between 1.20 in *Cola gigantean* to 48.82mg/100g in *Artocarpus altilis* edible
99 samples. The vitamin E contents ranged from traces in *Olox viridis*, *Napoleana imperialist* and
100 *Icacina trichatha olive* to 11.99mg/100g in *Artocarpus altilis* samples.

101 **4. DISCUSSION**

102

103 **4.1 Proximate analysis**

104 **4.2 Moisture**

105 In the study, the moisture content of the underutilized vegetables were between 60.45-
106 91.00%/100g sample. The result of the present study is in line with the value reported by Sheela
107 et al. (5) who observed that the moisture content of thirty eight underutilized green leafy
108 vegetables in Southern Karnataka were between the range of 68.00-93.00%. Fasoyiro et al. (9)
109 observed that the moisture content of fruits were from 78.24-84.81%. This falls within the range
110 of values obtained in this study (54.34-80.30%). The high moisture content in these vegetables
111 and fruits were not a surprise as Ene-Obong (10) noted that the most single constituent of fruits
112 and vegetable is water, which accounts for more than 80% of the nutrients. This will result to
113 lower contribution of other proximate components. The high moisture content of these fruits and
114 vegetables indicates that they will not have a long keeping quality.

115 **4.3 Protein**

116 The protein values (0.02-6.60%) obtained for these vegetables varied. Although vegetables are
117 not good sources of protein, *Ficus elsticoides* had a high protein level (6.60%). Eyo et al. (11)
118 observed that the protein levels of some vegetables are comparable to those of cereals (7.90%).
119 The high protein content of *Ficus elsticoides* could be useful in fighting kwashiorkor in

120 communities where protein energy malnutrition is prevalence provided it is consumed in
121 significant quantity. The protein value obtained for the fruits were 0.27-6.21%. Inclusion of 100g
122 portion size of *Ficus elsticoides* (6.60% protein), *Irvingia gabonensis* (6.21% protein) and
123 *Sterculiar spp* (6.04% protein) as shown in the pictorial record to the diet may be capable of
124 providing more than one-fifth of protein which will satisfy the RNI (27g protein) for children
125 (12).

126 **4.4 Fat**

127 Generally, vegetables and fruits are not good sources of fat. The result of the study confirms this
128 claim (0.02-2.19% fat) for vegetables and (traces-3.08% fat) for fruits. Consumption of these
129 vegetables and fruits may help to reduce high incidence of obesity, diabetes, cardiovascular
130 diseases, high blood pressure, which are associated with high intake of fatty foods. The results of
131 the vegetables were in line with the values reported by Sheela et al. (5) (0.20-2.60%).

132 **4.5 Crude fibre**

133 The crude fibre levels of the underutilized vegetables (0.04-5.01%/100g) and fruits (0.11-
134 8.58%) are of interest. The high fibre contents of *Pterocarpus santalinoides* (4.30%), *Bombaceae*
135 *spp* (5.01%) and *Olox viridis* (8.58%) could provide bulk in the diet, enhance gastrointestinal
136 function, prevent constipation and may reduce the incidence of metabolic diseases like maturity
137 onset diabetes mellitus and hypercholesterolemia (13). Portion size as shown for 100g of *Olox*
138 *viridis* if consumed in a day may provide more than one-third of the (RNI) for fibre which is 18g
139 (14).

140 **4.6 Ash**

141 *Landolfolia dulcis* fruit (11.05%) with high ash content suggests that the mineral content of this
142 fruit may be high. The ash levels of foods are an indication of the mineral content of the food.
143 The values (0.60-3.40%) reported by Ajayi et al.(15) as the ash contents of some leafy vegetables
144 studied were within the range of values observed in this study (0.04-4.20%).

145 **4.7 Carbohydrate**

146 Vegetables and fruits are not major sources of carbohydrates compared to starchy foods, which
147 form the bulk of food eaten. The very low carbohydrate contents of *Portulace oleraceae*
148 (10.30%), *Ficus sur* vegetables (11.17%), *Phyllanthus debilis* (9.08%) and *Ficus sur* fruit

149 (10.48%) is of interest. This is because low carbohydrate foods are good for people with obesity,
150 high blood pressure and diabetes mellitus challenges.

151 **4.8 Vitamins and Beta-carotene**

152 **4.9 Ascorbate**

153 The ascorbic acid values (2.40-38.40mg) for all the vegetables studied were within the range of
154 values (3.00-75.00mg) as observed by Sheela et al. (5) on 28 underutilized vegetables studied in
155 Tanzania. The high ascorbate value for *Portulaca oleraceae* (38.40mg), *Artocarpus altilis*
156 (48.82mg) and *Ficus sur* fruit (40.22mg) is of interest. Consumption of adequate quantities of the
157 fruits and vegetables with iron rich foods will enhance the absorption of iron. Ascorbic acid is
158 important in connective tissue and for proper absorption of iron and calcium. Adequate intake of
159 the fruits and vegetables may assist in the prevention of early death from heart diseases and
160 cancer and may also play a primary role in collagen formation which is essential for the growth
161 and repairs of tissue cells, gums, blood vessels, bones and teeth. Vitamin C is an important
162 antioxidant. The high Vitamin C level in the fruits and vegetables may help to battle against
163 cancer and many degenerative diseases (i.e. Alzheimer's, Cardiovascular Disease, Diabetes, etc).
164 (16).

165 **4.10 Vitamin E**

166 The high vitamin E content of some of the fruits and vegetables is desirable. Vitamin E is a
167 powerful antioxidant thus neutralizing free radicals in the body that causes cellular damage. It
168 also contributes to a healthy circulatory system and aids in proper blood clotting and improves
169 wound healing. Some studies have shown that vitamin E decreases symptoms of premenstrual
170 syndrome and certain types of breast disease (17). *Artocarpus altilis* fruit had 11.99mg/100g
171 vitamin E, *Phyllanthus debilis* fruit had 8.00mg/100g, while *Blighia unijugata* vegetables had
172 6.67mg/100g. Portion size as shown for 100g of *Artocarpus altilis* (11.99mg/100g) and
173 *Phyllanthus debilis* fruit (8.00mg/100g), could provide half of the daily RNI need of vitamin E
174 for breastfeeding mothers (16.80mg), adult men, women and pregnant women (13.20mg) (18).

175 **4.11 Beta-carotene**

176 The high beta-carotene levels (15.20-1933.00RE) of the vegetables are not a surprise. Eyo et al.
177 (11) observed that the yellow and green colours of vegetables indicate carotene, which is a

178 precursor of vitamin A. Consumption of 100g of majority of the vegetables studied as shown in
179 the pictorial record (*Vitex doniana*-1933.33RE, *Ficus vogaliana*-163333RE, *Ceiba pentandra*-
180 1866.67RE, *Pterocarpus santalinoides*-1233.33RE, *Moraceae spp*-450.00RE, *Bombaceae spp*-
181 616.67RE, *Blighia unijugata* -591.67RE, *Brillantaisi nitens*- 700.00RE, *Vaccinium parvifolium*-
182 451.67RE, and *Gssampelus mucanta*- 701.67RE) could provide the RNI (400RE) for
183 provitamin A (19). Majority of the fruits (*Nauclea diderrichii*-1233.33 RE, *Spondian mombin*-
184 2000.00 RE, *Vitex doniana*-1333.33 RE, *Afromomium daniella*-566.67 RE, *Myristicaceae spp*-
185 4333.33 RE, *Irvingia gabonensis*-416.67 RE, *Cola parchycarpa*-5666.67 RE and *Parkia*
186 *clappatonia*-970.67 RE) have high beta carotene which are higher than the RNI (400RE) for
187 Provitamin A. High level of beta-carotene in some of the vegetables and fruits is particularly
188 important if they are consumed in significant quantity to reduce incidence and severity of
189 respiratory tract infection of which pneumonia is the most serious (20). High consumption of the
190 vegetables and fruits could help to maintain normal vision, promote healthy cell growth, improve
191 iron utilization, gene expression, reproductive system, embryonic development, growth and
192 immune function (21).

193 4.12 Minerals

194 4.13 Iron (Fe)

195 The high iron content of *psychotria viridis* (11.80mg), *Napoleana imperialist* (9.40mg),
196 *Hippocretae myrint* (9.60mg), *Afromomium daniella* (8.40mg), *Portulace oleraceae* (10.50mg),
197 *Ficus fur* (10.60mg) and *Berlinia grandflora* (8.80mg) has nutritional significance. The fruits
198 and vegetables with their high ascorbate levels could be useful in the fight against iron
199 deficiency anemia. Vitamin C enhances the absorption of nonheme iron. The ascorbate levels
200 for each of the fruits and vegetables were *psychotria viridis* (29.90mg), *Portulace oleraceae*
201 (38.40mg), *Hippocretae myrint* (22.70mg), *Afromomium daniella* (14.80mg), *Ficus fur*
202 (11.60mg) and *Berlinia grandflora* (11.40mg). Consumption of 100g portion size of *psychotria*
203 *viridis* (11.80mg Fe), *Napoleana imperialist* (9.40mg Fe), *Hippocretae myrint* (9.60mg Fe),
204 *Afromomium daniella* (8.40mg Fe), *Portulace oleraceae* (10.50mg Fe), *Ficus fur* (10.60mg Fe)
205 and *Berlinia grandflora* (8.80mg Fe) may provide more than half of the RNI, for iron
206 (12.00mg/day) (22). The result indicated that the iron content of some of the vegetables (1.40-
207 11.80mg) were higher than those reported by Nnamani et al. (23) (3.68-7.34mg) and Maundu

208 (24) (0.70-8.90mg) on underutilized vegetables. The highest iron level was obtained from
209 *psychotria viridis* (11.80mg) vegetables.

210 **4.14 Copper (Cu)**

211 Copper is not found in large quantity in fruits and vegetables. The values (traces-4.06mg)
212 observed for fruits were in line with the values (0.60-3.80mg) observed by Umran and Nevo (25)
213 on fruits. Decuypene (22) observed that the estimated safe and adequate intake of copper per
214 day is 1.50-3.00mg. Thus including 100g portion size of *Cola parchycarpa* fruits (2.01mg) and
215 *Blinghia unijugata* vegetables (2.28mg) in daily diet ensures up to 50% of the daily RNI for
216 copper. Daily consumption of 100g portion size of *Gongronema spp* (4.06mg) and *Ipomea batata*
217 (3.14mg) may provide 100% RNI for copper which is an important component of many redox
218 enzymes, including cytochrome oxidase (26).

219 **4.15 Zinc (Zn)**

220 The zinc contents of the vegetables studied were between 1.30-9.40mg/100g. The zinc levels in
221 the fruits (0.02-10.30mg) were in line with the report of Umran et al. (27) who observed zinc
222 levels of 1.80-9.10 mg on fruits. The zinc levels of *Vitex doniana* (9.40mg) and *Hippocretae*
223 *myrint* (10.30mg) are of interest since plant foods are not major sources of zinc. Lippard and
224 Berg (26) stated that zinc is a trace mineral element that plays a catalytic role in enzymes. The
225 RNI of Zn is 200mg/day. Shankar and Prasad (28) observed that zinc enrichment may be
226 beneficial for health, but excess zinc may interact with Fe and Cu metabolism. Intake of
227 significant quantity of the vegetables with high zinc levels (*Vitex doniana* (9.40mg) and
228 *Hippocretae myrint* (10.30mg)) could reduce the duration and severity of diarrhea for infants and
229 young children with acute diarrhea.

230 **4.16 Manganese (Mn)**

231 Consumption of 100g portion size of some of the vegetables and fruits such as *Ficus vogaliana*
232 (4.80mg), *Hippocretae myrint* (6.60mg), *Icacina trichatha olive* (5.40mg), *Bombaceae spp*
233 (4.30mg), *Uvaria chamea* (3.60mg), and *Daniella olivera* (4.02mg) may provide the daily need
234 of manganese in both children and adult which is 2.00-5.00mg and 2.00-3.00mg, respectively

235 (22). The result of the fruits studied (0.10-6.60) were in line with the values reported by Umran
236 et al. (27) on fruits (0.70-5.70mg). Manganese is essential for processing oxygen (26).

237 **4.17 Calcium (Ca)**

238 Some of the vegetables studied are good sources of calcium. The values observed in this study
239 (18.19-400.00mg) for vegetables and values (5.42-46.50mg) for fruits are of interest. Inclusion
240 of 100g portion size of *Brillantaisi nitens* (400.00mg), *Irvingia gabonensis* (30.00mg)
241 *Pterocarpus santalinoides* (343.40mg), *Bombaceae spp* (252.00mg), *Berlinia grandiflora*
242 (340.00mg), *Ceiba pentandra* (261.50mg), *Daniella olivera* (281.90mg) and *Gssampelus*
243 *mucanta* (374.00mg) in daily diet may ensure 100% RNI (250mg calcium) for infants. Adequate
244 intake of fruits and vegetables could help in building the structural frame work of the body,
245 formation of bone, neutralize acidity, clear toxins and help blood stream (29).

246 **4.18 Magnesium (Mg)**

247 The result showed that some of these fruits and vegetables could provide some health benefits
248 as dietary components because they contain significant quantities of magnesium. *Phyllanthus*
249 *debilis* (31.82mg) and *Nauclea diderrichii* (26.10mg) has significant quantities of Mg.
250 Magnesium is required for processing ATP and related reactions, build bone, cause strong
251 peristalsis, increase flexibility, maintain blood pressure and acid –base balance (29Nelson and
252 Cox, 2000). Magnesium also helps in maintaining proper muscle functioning and keeping the
253 muscles relaxed, helps in absorbing calcium and phosphorus and is very important for proper
254 functioning of the nervous system (30).

255 **4.19 Sodium (Na)**

256 The sodium levels of the vegetables (0.27-3.01mg) were lower than the values reported by
257 Nnamani et al. (31) (7.00-21.00mg) and Taiyie and Asiebey-Berko (32) (6.44-21.82mg). The
258 values (traces-6.20mg) obtained in the fruits were in line with the values observed by Nevo (33)
259 (0.0-10.00mg) and Musinguzi et al. (34) (1.80-5.00mg) on fruits. Sodium is a very common
260 electrolyte; not generally found in plant foods and the RNI is 200mg/day (29). The ion is very
261 common in food; typically as sodium chloride, or common salt.

262 **4.20 Potassium (K)**

263 The potassium levels in the vegetables and fruits were 16.20-104.23mg and 2.43-410.00mg,
264 respectively. The following fruits and vegetables had high K levels - *Blinghia grandflora*
265 (104.23mg), *Hippocretae myrint* (281.00mg), *Napoleana imperialist* (110.00mg), *Spondian*
266 *mombin* (260.00mg), *Vitex doniana* (130.00mg), *Afromomium daniella* (198.00mg), *Cola*
267 *gigantean* (110.00mg), *Olox viridis* (240.00mg), *Phyllanthus debilis* (270.00mg), *Sterculia spp*
268 (180.00mg), *Myristicaceae spp* (156.00mg), *Ficus sur* (126.00mg), *Landofolia dulcis*
269 (210.00mg), *Parkia clappatonia* (220.00mg), *Gongronema spp* (192.00mg), *Irvingia gabonensis*
270 (410.00mg). Intake of significant quantities of the fruits and vegetables may be useful in
271 performing the functions of potassium in the body. Potassium is a common electrolyte that is
272 required for keeping the heart, brain, kidney, muscle tissues and other important organs of the
273 human body in good condition. It works in association with sodium to perform a number of
274 critical body tasks (35).

275 **4.21 Phosphorus (P)**

276 The vegetables studied are good sources of phosphorus (75.40-685.60mg). The values
277 determined in this study were higher than the values observed by Taiye and Asiebey-Berko (32)
278 (9.42-48.95mg); Nnamani et al. (312009) (37.00-57.00mg). The RNI for phosphorus is
279 200mg/day. Consumption of 100g of some of the vegetables like *Boerhavia diffusa* (685.60mg),
280 *Ipomea batata* (257.20mg), *Ficus elsticoides* (375.40mg), *Berlinia grandflora* (363.22mg), *Vitex*
281 *doniana* (602.00mg), *Vaccinium parvifolium* (339.12mg) and *Ficus fur* (444.25mg) would be
282 able to meet up with the RNI for phosphorus. Phosphorus is required to build healthy bones and
283 it is essential for energy metabolism (36).

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290 **Fig 1: Portion sizes of hundred gramme (100g) of underutilized vegetables analyzed.**



291 *Boerhavia diffusa*



Corchorus olitorius



Moraceae spp



292 *Portulence oleraceae*



Ceiba pentandra



Uvaria chamea

293



298 *Berlinia grandiflora*



Daniella olivera



psychotria viridis

303



304 *Vitex doniana*



Bombaceae spp

305



306 *Ficus vogaliana*



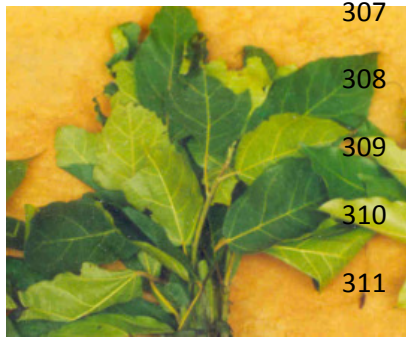
Brillantaisi nitens



Pterocarpus santalinoides



313 *Ipomea batata*



Blighia unijugata



Gssampelus mucanta



320 *Ficus elasticoides*



Ficus fur

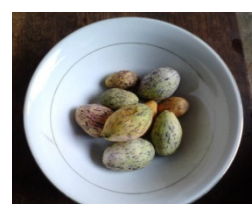
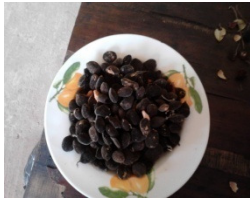
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322 Figure 1 shows the pictorial record of underutilized vegetables analyzed.

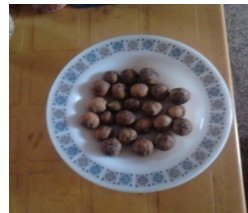
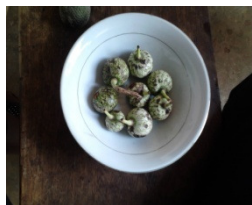
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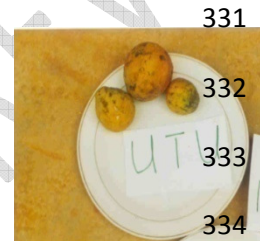
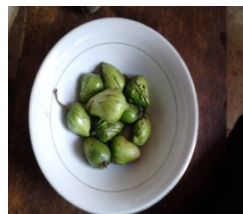
325 **Fig 3: Portion sizes of hundred grammes (100g) of the underutilized fruits analyzed.**



326 *Velvet tamarind* *Afromomium daniella* *Parkia clappatonia* *Artocarpus altilis* *Sterculiar spp*



330 *Phyllanthus debilis* *Irvingia gabonensis* *Myristicaceae spp* *Olax viridis*



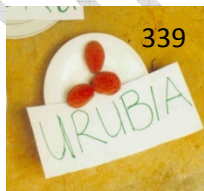
335 *Cola parchycarpa* *Hippocretae myrint* *Cola gingatean* *Landolfolia dulcis*

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338 *Napoleana imperialist* *Spondian mombin* *Ficus sur* *Nauclea diderrichii*

339 *Icacina trichatha olive*



Gongronema spp

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342 Figure 3 shows the pictorial record of underutilized fruits analyzed.

343 **Table 1a: Proximate composition of some underutilized vegetables on wet weight basis (%).**

Scientific Name	Moisture	Protein	Fat	Fibre	Ash	CHO
<i>Vitex doniana</i>	64.10±0.01	5.20±0.59	2.10±0.00	0.40±0.11	1.60±0.21	26.60±0.88
<i>Ficus elasticoides</i>	68.80±0.07	6.60±0.06	0.70±0.08	2.10±0.13	2.90±0.12	18.90±0.26
<i>Corchorus olitorius</i>	70.20±0.10	3.30±0.03	0.80±0.53	1.00 ±0.20	1.80±0.70	17.90±0.15
<i>Ficus vogaliana</i>	61.60±0.03	2.80 ±0.01	0.40±1.00	2.80±0.15	3.70±0.11	28.70±0.13
<i>Ceiba pentandra</i>	69.70±0.23	2.70±0.02	0.10±0.64	1.20± 0.60	0.90±0.030	25.40±0.04
<i>Portulace oleraceae</i>	80.20±0.05	4.80±0.06	0.10±0.81	1.20±0.04	1.40± 0.21	10.30±0.21
<i>Berlinia grandiflora</i>	74.20±0.23	1.22±0.02	1.27±0.64	1.92± 0.60	1.75±0.30	19.64±0.04
<i>Boerhavia diffusa</i>	65.90±0.07	3.60±0.15	0.20±0.02	1.60±0.18	2.40± 0.12	21.30±0.56
<i>Blinghia unijuta</i>	60.45±0.05	4.27±0.06	1.45±0.81	3.22±0.04	3.13± 0.21	27.48±0.21
<i>Daniella olivera</i>	71.10±0.04	3.90±0.01	0.40±0.04	1.70 ±0.01	0.90±0.73	18.00±0.15
<i>Brillantaisi nitens</i>	61.05±0.07	5.27±0.15	0.20±0.02	2.22±0.18	0.77±0.12	30.49±0.56
<i>Vaccinium parvifolium</i>	77.00±0.04	1.00±0.01	2.19±0.04	0.12 ±0.01	2.78±0.73	16.91±0.15
<i>Pterocarpus santalinoides</i>	60.80±0.04	4.20±0.05	0.40±0.08	4.30±0.02	4.20±0.90	26.10±0.31
<i>psychotria viridis</i>	66.40±0.14	1.40± 0.09	1.30±0.02	0.60±0.50	1.80±0.40	23.50±0.18
<i>Moraceae spp</i>	66.00±0.01	3.03±0.59	0.02±0.00	2.11±0.11	3.54±0.21	25.30±0.88
<i>Bombaceae spp</i>	91.00±0.07	0.02±0.06	0.90±0.08	5.01±0.13	0.92±0.12	2.15±0.26
<i>Uvaria chmea</i>	72.24±0.10	2.07±0.03	0.78±0.53	0.78 ±0.20	2.44±0.70	21.86±0.15
<i>Ficus sur</i>	84.22±0.03	0.22±0.01	2.11±1.00	0.04±0.15	2.24±0.11	11.17±0.13
<i>Ipomea batata</i>	68.12±0.14	2.12± 0.09	0.41±0.02	2.10±0.50	0.04±0.40	27.21±0.18
<i>Gssampelus mucanta</i>	80.23±0.04	0.48±0.05	0.62±0.08	1.16±0.02	1.11±0.90	16.40±0.31

Mean±Standard deviation

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347 **Table 1b: Proximate composition of some underutilized fruits on wet weight basis (%).**

ScientificName	Moisture	Protein	Fat	Fibre	Ash	CHO
<i>Hippocretae myrint</i>	72.40±0.09	0.30±0.10	0.10±0.19	0.28±0.66	0.55±0.74	26.37±0.30
<i>Nauclea diderrichii</i>	59.70±0.04	1.01±0.01	0.41±1.04	1.47±0.27	0.80±0.29	36.61±0.22
<i>Icacina trichatha olive</i>	73.50±0.40	0.90±0.06	0.37±0.43	0.11±0.03	0.73±0.30	24.39±0.63
<i>Myristicaceae spp</i>	60.90±0.63	1.20±0.21	0.52±0.36	0.93±0.80	0.68±0.75	35.77±0.35
<i>Artorcarpus altilis</i>	61.15±0.01	3.00±0.59	0.46±0.00	7.94±0.11	6.84±0.21	20.61±0.88
<i>Landolfolia dulcis</i>	70.40±0.07	2.08±0.06	1.52±0.08	1.48±0.13	11.05±0.12	13.47±0.26
<i>Cola parchcarpa</i>	59.27±0.03	4.57 ±0.01	1.03±1.00	3.67±0.15	5.72±0.11	25.74±0.13
<i>Gongranema spp</i>	75.40±0.23	2.60±0.02	Trace	1.38± 0.60	0.66±0.0.30	19.96±0.04
<i>Irvingia gabonensis</i>	67.42±0.05	6.21±0.06	1.65±0.81	7.80±0.04	4.80± 0.21	12.12±0.21
<i>Olox viridis</i>	73.10±0.33	0.72±0.71	0.39±0.01	0.39±0.10	0.71±0.52	25.08±0.44
<i>Napoleana imperialist</i>	70.90±0.28	0.70± 0.03	0.31±0.24	0.40±0.11	0.39±0.47	27.30 ±0.12
<i>Parkia clappatonia</i>	54.34±0.10	3.02±0.03	3.08±0.53	2.74 ±0.20	3.91±0.70	32.91±0.15
<i>Afromomium daniella</i>	71.30±0.36	0.27±0.07	0.27±0.26	1.01±0.60	0.65±0.78	26.50±0.16
<i>Vevet tamarind</i>	72.80±0.50	0.31±0.03	0.47±0.49	0.36±0.09	0.44±0.83	25. 62±0.53
<i>Cola gigantean</i>	71.02±0.04	2.11±0.01	2.38±0.04	1.17 ±0.01	0.33±0.73	22.99±0.15
<i>Ficus sur</i>	63.85±0.04	5.52±0.05	2.05±0.08	8.58±0.02	9.52±0.90	10.48±0.31
<i>Phyllanthus debilis</i>	80.30±0.14	3.42± 0.09	2.00±0.02	4.20±0.50	1.00±0.40	9.08±0.18
<i>Spondian mombin</i>	67.20±0.30	1.20±0.20	0.20± 0.06	2.02±0.02	3.00±0.62	26.38±0.74
<i>Vitex doniana</i>	61.70±0.04	1.30±0.30	2.50 ±0.41	0.76 ±0.06	2.79±0.13	30.95 ±0.0
<i>Sterculia spp</i>	68.92±0.07	6.04±0.15	1.46±0.02	5.27±0.18	3.36± 0.12	14.95±0.56

348 Mean±Standard deviation

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353 **Table 2a: Mineral composition of some underutilized vegetables on wet weight basis (mg/100g).**

Scientific name	Fe	Cu	Zn	Mn	Ca	Mg	Na	K	P
<i>Vitex doniana</i>	2.90±0.04	0.40±0.01	9.40±0.22	1.70±0.72	134.04±0.16	37.70±0.56	1.65±0.11	92.24±1.42	602.50±4.22
<i>Ficus elsticoides</i>	6.40±0.22	1.30±0.79	4.30±0.03	3.80±0.03	101.60±0.54	18.20±0.10	1.92±0.76	96.01±0.93	375.40±0.79
<i>Corchorus olitorius</i>	1.60±0.01	0.66±0.39	6.90±0.08	2.32±0.04	238.00±0.67	17.50±0.34	2.30±0.36	83.33±0.16	128.20±2.22
<i>Ficus vogaliana</i>	6.20±0.19	1.22±0.77	2.90±0.15	4.80±0.09	240.60±0.44	20.10 ±0.80	1.88±0.72	53.87±0.23	75.40±7.06
<i>Pterocarpus santalinoides</i>	3.10±0.14	0.40±0.66	1.80 ±0.56	0.30±0.12	343.40±2.08	17.70±0.45	1.02±0.16	80.11±0.49	85.00±10.30
<i>psychotria viridis</i>	11.80±0.23	1.30±0.43	7.00±0.55	1.32±0.88	116.20±0.96	22.60±0.64	3.01±0.20	76.27±0.78	134.60±6.13
<i>Moracae spp</i>	2.60±0.04	0.02±0.01	Trace	0.60±0.72	180.40±0.16	32.14 ±0.56	0.64±0.11	96.14±0.23	154.28±1.22
<i>Bombaceas spp</i>	1.40±0.22	0.60±0.79	2.10±0.03	4.30±0.03	252.00±0.54	25.60±0.10	2.33±0.76	70.92±0.93	220.91±0.79
<i>Uvaria chamea</i>	6.80±0.01	0.90±0.39	1.70±0.08	3.60±0.04	220.00±0.67	47.20±0.34	3.01±0.36	48.00±0.16	161.45±1.22
<i>Ficus sur</i>	10.60±0.19	0.40±0.77	0.40±0.15	1.30±0.09	18.19±0.44	42.26 ±0.80	2.13±0.72	54.00±0.23	444.25±0.06
<i>Berlinia grandiflora</i>	8.80±0.11	0.30±0.32	1.60±0.27	0.20±0.49	340.00±0.63	18.34±0.16	1.98±0.65	104.23±0.17	363.22±0.14
<i>Blighia unijugata</i>	3.45±0.54	2.28±0.17	2.06±0.32	0.74±0.07	96.20±0.24	4.38±0.74	0.72±0.42	23.23±0.01	126.22±5.02
<i>Brillantaisi nitens</i>	1.40±0.23	0.20±0.04	1.40±0.81	2.60±0.43	400.00±5.38	41.00±0.28	0.27±0.31	16.20±0.03	216.00±0.70
<i>Ceiba pentandra</i>	3.60±0.11	0.10±0.32	5.30±0.27	0.60±0.49	261.50±2.63	15.17±0.16	2.10±0.65	46.20±0.17	154.10±3.14
<i>Boerhavia diffusa</i>	6.10±0.15	0.95±0.0.18	5.20±1.02	0.07±0.31	219.60±0.42	28.22±0.05	1.44±0.01	61.92±0.14	685.60±9.53
<i>Daniella olivera</i>	2.00±0.23	0.93±0.04	1.30±0.81	4.02±0.43	281.90±38	16.19±0.28	0.92±0.31	56.13±0.03	187.90±2.70
<i>Vaccinium parvifolium</i>	5.27±0.14	1.62±0.66	0.78 ±0.56	2.27±0.12	43.00±0.08	38.40±0.45	1.10±0.16	71.21±0.49	339.12±1.30
<i>Gssampelus mucanta</i>	2.76±0.23	0.98±0.43	3.21±0.55	0.91±0.88	374.00±2.96	16.10±0.64	2.15±0.20	57.20±0.78	122.20±0.13
<i>Ipomea batata</i>	1.91±0.15	3.14±0.18	3.96±1.02	1.67±0.31	140.00±0.42	20.11±0.05	2.02±0.01	49.61±0.12	257.20±16.53
<i>Portulace oleraceae</i>	10.50±0.54	0.33±0.17	1.40±0.32	1.71±0.07	144.40±0.24	27.14±0.74	1.62±0.42	52.10±0.01	152.90±1.02

354 Mean ± Standard deviation

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357 **Table 2b: Mineral composition of some underutilized fruits on wet weight basis (mg/100g).**

Scientific name	Fe	Cu	Zn	Mn	Ca	Mg	Na	K	p
<i>Hippocretae myrint</i>	9.60±0.16	0.03±0.00	10.30±0.04	6.60±0.20	13.04±0.02	3.00±0.03	1.00±0.03	281.00±6.18	20.00±0.93
<i>Nauclea diderrichii</i>	4.80±0.29	0.02±0.02	1.70±0.03	2.80±0.18	9.20±0.11	26.10±0.13	3.00±0.01	60.00±0.17	9.00±0.83
<i>Icacina trichatha olive</i>	2.10±0.11	0.04±0.01	2.80±0.21	5.40±0.47	20.70±0.03	10.40±0.14	3.00±0.19	29.42±0.08	13.00±0.42
<i>Napoleana imperialist</i>	9.40±0.43	0.02±0.01	0.60±0.13	0.30±0.07	28.10±0.08	9.60±0.10	3.00±0.55	110.00±2.08	21.00±0.40
<i>Spondian mombin</i>	2.12±0.22	0.01±0.12	6.03±0.09	3.10±0.11	17.91±0.10	15.00±0.06	4.50±0.18	260.00±4.14	39.00±0.02
<i>Vitex doniana</i>	3.40±0.35	0.12±0.43	4.40±1.04	2.61±0.24	12.16±0.06	9.27±0.41	4.00±0.26	130.00±0.49	19.00±0.01
<i>Afromomium daniella</i>	8.40±0.09	0.01±0.04	0.40±0.04	0.10±0.28	17.20±0.03	2.04±0.15	Trace	281.00±3.04	14.00±0.05
<i>Vevet tamarind</i>	9.80±0.27	0.04±0.03	8.60±0.11	0.50±0.02	14.71±0.06	18.12±0.07	1.55±0.05	198.00±0.01	18.00±0.21
<i>Irvingia gabonensis</i>	2.00±0.54	0.30±0.17	2.20±0.32	1.21±0.07	30.00±0.24	3.00±0.74	6.20±0.42	410.00±1.01	1.70±0.02
<i>Cola gingatean</i>	1.70±0.23	0.04±0.04	0.10±0.81	0.32±0.43	27.00±0.38	8.64±0.28	1.17±0.31	110.00±0.03	12.34±0.70
<i>Ficus sur</i>	1.43±0.14	0.02±0.66	1.29±0.56	2.27±0.12	31.20±0.08	3.25±0.45	1.61±0.16	240.00±1.49	39.42±0.30
<i>Phyllanthus debilis</i>	3.20±0.23	1.00±0.43	0.20±0.55	0.42±0.88	46.50±0.96	31.82±0.64	0.20±0.20	270.00±0.78	37.10±0.13
<i>Sterculiar spp</i>	1.04±0.15	Trace	0.42±1.02	0.11±0.31	22.50±0.42	18.03±0.05	2.00±0.01	180.00±0.14	20.13±0.53
<i>Myristicaceae spp</i>	6.40±0.59	0.04±0.29	2.30±0.35	4.40±0.74	19.09±0.17	14.72±0.14	2.00±0.11	156.00±0.18	12.00±0.19
<i>Olox viridis</i>	3.60±0.35	0.00	0.10±0.61	0.30±1.09	18.47±0.22	12.88±0.56	1.00±0.40	126.00±0.60	14.00±0.26
<i>Artocarpus altilis</i>	4.76±0.04	0.02±0.01	1.42±0.22	3.17±0.72	11.30±0.16	4.60±0.56	2.17±0.11	2.43±0.23	11.46±0.22
<i>Landolfolia dulcis</i>	3.85±0.22	0.03±0.79	0.02±0.03	0.98±0.03	5.42±0.54	3.02±0.10	1.80±0.76	210.00±0.93	3.85±0.79
<i>Parkia clappatonia</i>	2.90±0.01	0.06±0.39	0.80±0.08	0.40±0.04	18.00±0.67	0.21±0.34	3.70±0.36	220.00±0.16	28.21±0.22
<i>Cola parchycarpa</i>	3.40±0.19	2.01±0.77	1.82±0.15	1.38±0.09	32.10±0.44	1.71±0.80	4.12±0.72	96.00±0.23	6.79±0.06
<i>Gongronema spp</i>	0.10±0.11	4.06±0.32	2.43±0.27	1.72±0.49	9.96±0.63	16.63±0.16	4.47±0.65	192.00±0.17	44.66±0.14

358 Mean ± Standard deviation

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360 **Table 3a: B-carotene and Vitamin composition of some underutilized vegetables on wet**
 361 **weight basis.**

Scientific name	B-carotene (RE)	VitaminC (mg)	VitaminE (mg)
<i>Vitex doniana</i>	1933.33±21.59	12.10±0.35	0.96±0.11
<i>Ficus elsticoides</i>	15.20±0.29	32.90±0.09	0.11±0.91
<i>Corchorus olitorius</i>	16.00±0.35	3.60±0.02	1.92±0.76
<i>Ficus vogaliana</i>	1633.33±8.74	6.50±1.00	1.24±0.40
<i>Ceiba pentandra</i>	1866.67±18.17	12.20±0.26	3.11±0.01
<i>Portulace oleraceae</i>	31.20±0.14	38.40 ± 0.62	2.10±0.46
<i>Daniella olivera</i>	22.40±0.11	3.04±0.14	0.87±0.19
<i>Pterocarpus santalinoides</i>	1233.33±6.18	11.20 ±0.22	2.41±0.02
<i>psychotria viridis</i>	25.67±0.01	29.90±0.14	2.63±0.56
<i>Boerhavia diffusa</i>	1366.67± 0.19	16.10 ±0.60	1.86±0.08
<i>Moraceae spp</i>	450.00±0.59	2.40±0.35	Trace
<i>Bombaceae spp</i>	6161.67±1.29	12.80±0.09	1.24±0.91
<i>Uvaria chemea</i>	200.00±0.35	14.30±0.02	0.08±0.76
<i>Ficus sur</i>	356.67±2.74	11.60±1.00	0.67±0.40
<i>Blinghia unijugata</i>	591.67±1.14	4.12 ± 0.62	6.67±0.46
<i>Brillantaisi nitens</i>	700.00±0.11	14.20±0.14	1.12±0.19
<i>Vaccinium parvifolium</i>	451.67±2.18	5.27 ±0.22	3.25±0.02
<i>Gssampelus mucanta</i>	266.83±0.01	19.60±0.14	4.98±0.56
<i>Ipomea batata</i>	701.67± 0.19	8.67 ±0.60	5.57±0.08
<i>Berlinia grandflora</i>	356.67±1.17	11.40±0.26	3.36±0.01

362 Mean±Standard deviation

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372 **Table 3b: B-carotene and Vitamin composition of some underutilized fruits on wet weight**
 373 **basis.**

Scientific name	VitaminC (mg)	VitaminC (mg)	B-carotene (RE)
<i>Hippocretae myrint</i>	22.70±0.09	22.70±0.09	Trace
<i>Nauclea diderrichii</i>	13.40±0.05	13.40±0.05	1233.33±6.62
<i>Icacina trichatha olive</i>	4.90±0.42	4.90±0.42	16.67±0.94
<i>Napoleana imperialist</i>	3.80±0.14	3.80±0.14	Trace
<i>Spondian mombin</i>	9.30±0.07	9.30±0.07	2000.00±9.71
<i>Vitex doniana</i>	14.29±0.03	14.29±0.03	1333.33±0.76
<i>Afromomium daniella</i>	14.80±0.01	14.80±0.01	566.67±0.73
<i>Vevet tamarind</i>	8.60±0.16	8.60±0.16	Trace
<i>Myristicaceae spp</i>	14.90±0.07	14.90±0.07	4333.33±11.03
<i>Olox viridis</i>	2.40± 0.11	2.40± 0.11	16.67± 0.09
<i>Artocarpus altilis</i>	48.82±0.35	48.82±0.35	199.83±4.59
<i>Irvingia gabonensis</i>	35.80 ± 0.62	35.80 ± 0.62	416.67±2.14
<i>Cola gigantean</i>	1.20±0.14	1.20±0.14	46.67±0.11
<i>Ficus sur</i>	40.22 ±0.22	40.22 ±0.22	665.00±1.18
<i>Phyllanthus debilis</i>	14.26±0.14	14.26±0.14	141.67±0.01
<i>Sterculia spp</i>	13.68 ±0.60	13.68 ±0.60	60.00± 0.19
<i>Landolfolia dulcis</i>	17.40±0.09	17.40±0.09	48.33±0.29
<i>Parkia clappatonia</i>	18.90±0.02	18.90±0.02	970.67±1.35
<i>Cola parchycarpa</i>	11.61±1.00	11.61±1.00	5666.67±2.74
<i>Gongronema spp</i>	14.48±0.26	14.48±0.26	17.5±0.17

374 Mean ± Standard deviation

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377 5. CONCLUSION

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379 The result of the study showed that *Phyllanthus debilis* is a good source of minerals especially
 380 magnesium and calcium. Some of the fruits and vegetables like *psychotria viridis*, *Napoleana*
 381 *imperialist*, *Hippocretae myrint*, *Afromomium daniella*, *Portulace oleraceae*, *Ficus fur* and
 382 *Berlinia grandiflora* are good sources of iron. The vegetables could be useful in dietary
 383 formulations to fight iron deficiency anaemia. This important attribute of the vegetables should
 384 be explored. *Vitex doniana* and *Hippocretae myrint* are rich in zinc despite the fact that plant

385 foods are not good sources of zinc. The high protein levels of some of the fruits and vegetables
386 like *Ficus elsticoides*, *Irvingia gabonensis* and *Sterculiar spp* suggest that they could be used in
387 dietary formulation or in supplementing low protein foods in the diet.

388 *Vitex doniana*, *Ficus vogaliana*, *Ceiba pentandra*, *Pterocarpus santalinoides*, *Moraceae spp*,
389 *Bombaceae spp*, *Blighia unijugata*, *Brillantaisi nitens*, *Vaccinium parvifolium*, *Gssampelus*
390 *mucanta*, *Nauclea diderrichii*, *Spondian mombin*, *Vitex doniana* fruits, *Afromomium daniella*,
391 *Myristicaceae spp*, *Irvingia gabonensis* pulp, *Cola parchycarpa* and *Parkia clappatonia* has high
392 levels of beta carotene. Consumption of the vegetables and fruits in adequate quantity could help
393 to alleviate the problems associated with vitamin A deficiency. *Portulace oleraceae*, *Artocarpus*
394 *altilis* and *Ficus sur* fruit are high in ascorbate which is a powerful antioxidant that could help
395 fight degenerating diseases. If the vegetables and fruits are consumed with iron rich foods, the
396 high ascorbate level will facilitate iron absorption. *Artocarpus altilis* fruit, *Phyllanthus debilis*
397 fruit, and *Blighia unijugata* vegetables are rich in vitamin E which is a common antioxidant.

398

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