

Evaluation of the nutrients, antinutrients and metals content of five leafy vegetables in Dengi metropolis

ABSTRACT

Aim: To quantify the levels of amino acids, some metals, and phytochemicals/antinutritional factors in leafy vegetables: *Cucurbita pepo*, *Vitex doniana*, *Hibiscus cannabinus*, *Leptadenia hastata*, *Balanites aegyptiaca*.

Study design: The research work is descriptive.

Place and duration of study: Department of Biochemistry, University of Jos between March 2016 and September 2016.

Methodology: 5 samples each of the vegetables were collected at random from different locations in the area of study. Atomic Absorption Spectrophotometry was applied to analyse for metals. Levels of amino acids in samples were determined using the PTH amino acids analyser. Antinutrients were quantified using standard methods. One way ANOVA was used to analyse the data obtained at 95% level of significance.

Results: Mean levels of Pb and Cd were 0.030 ± 0.01 ppm and 0.004 ± 0.001 ppm respectively ($P > 0.05$) relative permissible limits. Mean Mg, Mn and Fe content were 1.084 ± 0.02 ppm, 0.069 ± 0.01 ppm and 1.534 ± 0.10 ppm respectively ($P = .05$). Amino acids profile indicated mean values (g/100g proteins) of Glutamate 8.34, Aspartate 8.14, Leucine 8.34, Lysine 4.03, Isoleucine 3.30, Phenylalanine 4.17, Tryptophan 2.25, Valine 4.6, Methionine 1.12, Proline 2.84, Arginine 4.99, Tyrosine 2.75, Histidine 2.23, Cysteine 1.09, Alanine 3.71, Glycine 4.08, Threonine 2.88, Serine 2.99. Mean range of antinutrients were: tannins, 0.51 ± 0.13 % to 0.60 ± 0.12 %, oxalates, 0.14 ± 0.14 % to 0.60 ± 0.20 %, phytates, 1.70 ± 0.01 mg/100g to 4.10 ± 0.01 mg/100g, saponins, 11.85 ± 1.85 % to 15.13 ± 1.50 %, cyanogenic glycosides, 4.82 ± 1.30 % to 7.59 ± 1.20 %, total alkaloids and total flavonoids were 16.22 ± 1.61 % to 19.37 ± 1.23 % and 9.87 ± 1.32 % to 14.71 ± 2.30 % respectively.

Conclusion: Although samples analysed contained significant amounts of antinutrients, they are very good sources of amino acids; especially Lysine, Methionine, Leucine, tryptophan which are essential; and mineral elements. Levels of lead and cadmium in the samples were lower than safe limits. These vegetables are good sources of nutrients. Their consumption will replenish nutrients to the cell thereby improving the well being of consumers.

Key words: amino acids, antinutrients, nutrients, metals, vegetables

42

43 **INTRODUCTION**

44 Leafy vegetables have been shown to be valuable sources of nutrients (Nesamvuni *et al.*,
45 2001) with some having medicinal properties (Hilou *et al.*, 2006). These vegetables serve as valuable
46 sources of nutrients especially in rural areas where they exist in the open country. They might contain
47 significant levels of trace elements, heavy metals, amino acids as well as antinutrients. Leafy
48 vegetables can contribute substantially to food security in the rural areas where people's diet is based
49 on mostly carbohydrates and legumes which are high in calories but deficient in essential
50 micronutrients and proteins (Yiridoe and Anchirinah, 2005).

51 Heavy metals such as arsenic, cadmium, lead are toxic to cells (Schumacher *et al.*, 1991),
52 thus it is important to determine their levels in especially in plant-based foods and diets. In general,
53 information on edibility and therapeutic properties of wild plants is scanty but data on their nutritional
54 composition and mineral content is negligible (Aloskar *et al.*, 1992). Manganese is an essential trace
55 element, which plays an important role as a cofactor for many enzyme systems such as hexokinase
56 and superoxide dismutase. At high level however, it can cause damage to the brain (Aschner and
57 Aschner, 2005). Magnesium is another nutrient required in the plasma and extra cellular fluid, where it
58 helps in maintaining osmotic equilibrium. It is required in many enzyme-catalysed reactions,
59 especially those in which nucleotides participate where the reactive species is the magnesium salt (eg
60 MgATP²⁻). Lack of Mg is associated with abnormal irritability of muscle and convulsions whereas
61 excess levels implicated in depression (Aschner and Aschner, 2005).

62 Iron is necessary for the formation of haemoglobin and also plays an important role in oxygen
63 and electron transfer in human body (Kaya and Incekara, 2000). Also, in the functioning of the central
64 nervous system as well as oxidation of carbohydrates, proteins and fats (Adeyeye and Otokiti,
65 1999). Cadmium is a heavy metal that causes both acute and chronic poisoning; adverse effect on
66 kidney, liver, vascular and immune system (Heyes, 1997). Chronic exposure to chromium may result
67 in liver, kidney and lung damage (Zayed and Terry, 2003).

68 Lead causes both acute and chronic poisoning with the kidney and liver as primary targets. It inhibits
69 the catalytic action of δ -amino levulinic acid dehydratase (Porphobilinogen Synthase) in haem
70 biosynthetic pathway; toxic on the vascular and immune system (Heyes, 1997).

71 Antinutritional factors reduce the nutritive values of many plants due to their natural inherence
72 in the plants. They are capable of eliciting deleterious effect in man and animals (Kubmarawa *et al.*,
73 2008). Oxalate tends to render calcium unavailable by binding to the calcium ion to form complexes
74 (Nkafamiya *et al.*, 2009). Phytic acid acts as a strong chelator forming protein and mineral-phytic acid
75 complexes thereby decreasing protein and mineral bioavailability (Fasusi *et al.*, 2006). Phytate is
76 associated with nutritional diseases such as rickets and osteomalacia in children and adult,
77 respectively. Tannins are water soluble phenolic compounds with a molecular weight greater than 500
78 and with the ability to precipitate proteins from aqueous solution. They occur in all vascular plants.
79 Tannin binds to proteins making them bio unavailable (Bagepallis *et al.*, 1993). This seeks to quantify
80 both the nutrients and antinutrients in these plants samples.

81

82 **MATERIALS AND METHODS**83 **Materials**84 **Chemicals and reagents**

85 All reagents and chemicals were of analytical grade from BDH.

86 Equipment used

87 OHUAS digital balance, applied biosystems PTH amino acid analyzer and Soxhlet assembly set up.

88

89 Raw samples of the leafy vegetables were collected from different farms in and around Dengi
90 metropolis. They were destalked, washed and air dried. Samples were pulverised in ceramic mortar
91 and pestle. This was followed by sieving the samples to obtain fine particles.

92 Amino acids analysis

93 The amino acid profile was determined using the method described by Sparkman *et al.*(1958). Where
94 each of the dried samples were defatted(by refluxing 100g of the air-dried powdered samples with
95 250ml petroleum ether (600-800) for 4 hours, the resulting residue was then dried and subjected to
96 aqueous extraction using Soxhlet assembly. Extracts were thereafter evaporated and loaded into the
97 "applied biosystems PTH amino acid analyzer" which separated and analysed free acidic, neutral and
98 basic amino acids of the hydrolysate.

99 Determination of mineral elements content

100 The minerals content of the different samples was evaluated for Mn, Mg, Fe, Cd, Cr and Pb by dry
101 ashing of dried powdered sample (5g) in a muffle furnace set at 775°C. The ash obtained was
102 dissolved in 5 mL of 20% HCl and analysed using the atomic absorption spectrophotometer at their
103 respective wavelengths of maximum absorption (λ_{max}) thus: 385nm, 285.5nm, 405nm, 357.8nm,
104 582nm, 389.6nm for Mn, Mg, Fe, Cd, Cr and Pb in that order.

105 Determination of antinutrients

106 Tannins were quantified according to Bainbridge *et al.* (1996), total oxalate quantified applying Day
107 and Underwood (1986) method. Phytate content was determined by the Reddy and Love method
108 (1999).

109 Statistical Analysis

110 The statistical method employed for all the analysis was one way ANOVA and all results are means of
111 three determinations (\pm SD). $P = .05$ was considered significant.

112

113 RESULTS AND DISCUSSION

114 This research sought to assess the amino acids, antinutrients, phytochemicals and metals
115 composition of five commonly consumed leafy vegetables in Dengi metropolis. Green leafy
116 vegetables constitute an indispensable constituent of human diet in Africa generally and West Africa
117 in particular; the varieties of leafy vegetables utilized are diverse, ranging from leaves of annuals and
118 shrubs to leaves of trees. Leafy vegetables are generally good sources of nutrients, important
119 protective foods, highly beneficial for the maintenance of health and prevention of diseases as they
120 contain valuable food ingredients which can be utilized to build up and repair the body. They are
121 valuable in maintaining alkaline reserve in the body and are valued mainly for their high vitamin,
122 dietary fibre and mineral content (Olubunmi *et al.*, 2017). The dark green leaves and deep yellow
123 fruits provide a high amount of carotene, ascorbic acid and micro-minerals which play important roles
124 in nutrient metabolism and slowing down of degenerative diseases (Olubunmi *et al.*, 2017).
125

126 Eighteen amino acids were analysed in different proportions in the vegetables. The amino
127 acid contents are generally high in all samples with the highest, based on dry weight, observed in
128 *Letadenia hastata* (93.20g/100g protein) others range between 71.41g to 74.62g/100g proteins. Level
129 of Glutamic Acid was the highest amongst other amino acids in all samples (with an average 11.19
130 g/100g proteins) followed by Aspartic Acid with an average of 7.92g/100g proteins whereas Cysteine
131 and Methionine were low with average of 1.37g/100g proteins. All the samples analysed contained
132 high levels of Glutamate with *Letadenia hastata* have the highest level at 12.11g/g proteins. Levels of
133 Cysteine and Methionine in *Balanites aegyptiaca* were 0.78g/100g and 0.78g/100g proteins
134 respectively. The samples contain essential amino acids such as Methionine, Lysine, Leucine,
135 Isoleucine, Tryptophan, Phenylalanine, Valine and Histidine albeit the levels were lower than the non
136 essential amino acids. Leucine stimulates muscle strength and growth, regulate blood sugar level by
137 moderating insulin into the body during and after exercise and can even help prevent depression by
138 the way it acts on neurotransmitters in the brain (Guoyao, 2010). Lysine is responsible for proper
139 growth and in the production of carnitine (a nutrient responsible for converting fatty acids into fuel to
140 lower cholesterol). It also helps the body absorb calcium for further bone strength and also aids in
141 collagen production. Methionine helps form cartilage in the body through the use of sulphur. Histidine
142 is involved in transport neurotransmitters to the brain and also helps overall muscle health within each
143 muscle cells. Valine is needed for optimal muscle growth and repair(Guoyao, 2010).

144 Table 2 shows the mineral content of the vegetables. The permissible limit of iron set by
145 FAO/WHO (1984) in edible plants is 20 ppm. Iron is necessary for the formation of haemoglobin and
146 also plays an important role in oxygen and electron transfer in human body (Kaya and Incekara,
147 2000) and normal functioning of the central nervous system and in the oxidation of carbohydrates,
148 proteins and fats (Adeyeye and Otokiti, 1999), the highest iron content of 2.223 ppm was found in the
149 leaves of *Leptadenia hestata* while the leaves of *Balanites aegyptiaca* contain the least iron content of
150 0.772 ppm, the leaves of *Vitex doniana*, *Hibiscus cannabinus* and *Cucurbita pepo* have significantly
151 higher iron content of 1.081, 0.916 and 0.831 ppm, respectively. An average culinary preparation
152 contains about 300g of the fresh leaves of vegetables and this would result in an intake of 30g dry
153 weight leaves per serving portion. Therefore 1.081, 0.916 and 0.831 ppm in *Vitex doniana*, *Hibiscus*
154 *cannabinus* and *Cucurbita pepo* respectively, will contribute up to, in mg, 3.2, 2.7 and 2.3/serving
155 portion of Fe respectively, to the recommended dietary allowance of Fe (10- 15mg/day) (FAO/WHO,
156 2002).
157 Manganese level, in ppm, was found to be 0.133 in *Leptadenia hastata*, 0.065 in *Hibiscus*
158 *cannabinus*, 0.041 in *Balanites aegyptiaca*, 0.061 in *Cucurbita pepo* and 0.051 in *Vitex doniana* with
159 respectively.

160
161 In table 2, level of Mg, in ppm, was 1.091 in *Cucurbita pepo*, which is the highest compared to others
162 whose content ranged from 0.915 to 1.080. Mg is required in the plasma and extra cellular fluid,
163 where it helps in maintaining osmotic equilibrium (Ryan, 1991). It is required in many enzyme –
164 catalysed reactions, especially those in which nucleotide participate where the reactive species is the
165 magnesium salt, MgATP²⁻. Deficiency of Mg is associated with abnormal irritability of muscle, and
166 convulsions. Excess Mg predisposes to depression (Ryan, 1991).

167 Cadmium concentration, in ppm, of the samples ranged from 0.003 in *Hibiscus cannabinus* to
168 0.004 in *Leptadenia hestata*. These values are below the permissible limit of 0.212 set by FAO/WHO
169 (1984) in edible plant. In medicinal plants however, the permissible limit by WHO is 0.310. The low
170 level of Cd in all the samples means they are safe for consumption.

171 As for Pb content of the samples, *Leptadenia hestata* had 0.002 ppm whereas *Balanites*
 172 *aegyptiaca* contained 0.055 ppm. These levels in the samples are below the permissible level,
 173 0.43ppm (FAO/WHO 2004).

174 Results of the phytochemical analysis are presented in Table 3. Antinutritional factors have
 175 been shown to limit the use of many plants due to their ubiquitous occurrence as natural compounds
 176 capable of eliciting deleterious effect in man and animals (Kubmarawa *et al.*, 2008). The major
 177 antinutritional factors commonly found in green leafy vegetables are phytic acid, oxalic acid and
 178 tannins (Osagie and Offiong, 1998). High levels of phytates and oxalates have been shown to inhibit
 179 the absorption and utilization of minerals such as calcium by animals including man (Grases *et al.*,
 180 2017). Tannins decrease protein quality by reducing the digestibility and palatability; they interfere
 181 with absorption of iron and a possible carcinogenic effect (Spalinger *et al.*, 2010).

182 The oxalate content in these vegetables ranged between 0.14mg/100g in *Vitex doniana* to
 183 0.60mg/100g in *Cucurbita pepo*. These values are below the established toxic level (FAO/WHO,
 184 2004). The phytate level was between 1.7 mg/100g in *Cucurbitapepo* 4.1 mg/100g to *Leptadenia*
 185 *hastata*. Results obtained are below the toxic level (FAO/WHO, 2004). According to Oke (1989) a
 186 phytate diet of 1-6% over a long period of time decreases the bioavailability of mineral elements in
 187 mono gastric animals.

188 Cyanogens are glycosides of a sugar, sugars and cyanide containing aglycone. Cyanogens
 189 can be hydrolyzed by enzymes to release a volatile HCN gas (Nkafamiya and Manji, 2006). Excess
 190 cyanide ion inhibits the cytochrome oxidase which stops ATP formation and so tissues suffer energy
 191 deprivation and death follows rapidly. High level of HCN has been implicated for cerebral damage and
 192 lethargy in man and animal (Nkafamiya and Manji, 2006). In table 3, the levels were 7.59 % in
 193 *Cucurbita pepo* and 4.82% in *Balanites aegyptiaca* which are below lethal level as indicated on the
 194 table 3. As for saponins, level ranged between 11.85 % in *Leptadenia hastata* to 15.13 % in *Vitex*
 195 *doniana*. Saponins are glycosides containing polycyclic aglycone moiety of either C₂₇ steroid or
 196 C₃₀triterpenoids attached to a carbohydrate. High saponin level has been associated with
 197 gastroenteritis manifested by diarrhoea and dysentery (Sodipo *et al.*, 2000).

198 Tannins are water soluble phenolic compounds with a molecular weight greater than 500 and
 199 with the ability to precipitate proteins from aqueous solution. They occur in all vascular plants. Tannin
 200 binds to proteins making them bio unavailable (Bagepallis *et al.*, 1993). From the results, the level
 201 obtained was between 0.51% in *Balanites aegyptiaca* and 0.60 % in *Vitex donina*. There was no
 202 significant difference in the Tannin level among the vegetables (p>0.05).

203 Alkaloids have been implicated in the inhibition activities of many bacterial species
 204 (Nuhu *et al.*, 2000). The levels of alkaloids in the various leafy vegetables analysed ranges from
 205 16.22% observed in *Letadenia hastata* and 19.37% in *Vitex doniana*
 206 Plant phenolics such as flavonoids have been shown to have antioxidant properties and also
 207 contribute to their medicinal significance (Wong *et al.*, 2006). In this work, the levels of flavonoids
 208 ranged from 9.87 % in *Balanites aegyptiaca* to 14.71 % in *Vitex doniana*. Consumption of these
 209 vegetables would further enhance the capacity of the cell to mop up the highly reactive oxygen
 210 radicals generated due to oxidative metabolic reactions that occur in cells.

211

212 **TABLE 1:** Amino acid composition of the samples

AMINO ACIDS g/100g proteins	<i>Cucurbita pepo</i>	<i>Vitex doniana</i>	<i>Hibiscus cannabinus</i>	<i>Letadenia hastata</i>	<i>Balanites aegyptiaca</i>	MEAN	S.D	C.V %
L	8.14	6.48	7.29	8.34	6.48	7.35	0.88	12.03
K	4.03	3.63	3.97	5.54	4.37	4.31	0.74	17.11
I	3.30	3.01	2.94	4.78	3.40	3.49	0.75	21.47
F	4.17	4.43	4.34	5.58	4.70	4.64	0.56	12.00
W	2.25	1.26	2.10	2.86	1.12	1.92	0.72	37.78
V	4.50	3.59	4.00	5.61	4.09	4.36	0.77	17.69

M	1.12	1.23	1.71	2.00	0.80	1.37	0.48	34.95
P	2.84	3.14	2.84	4.57	2.23	3.12	0.87	27.96
R	4.99	6.11	5.33	7.83	4.99	5.85	1.20	20.47
Y	2.75	3.09	3.09	4.13	3.09	3.23	0.52	16.23
H	2.23	2.17	2.39	2.11	2.65	2.31	0.22	9.39
C	1.09	1.21	1.57	2.18	0.78	1.37	0.54	39.22
A	3.71	4.40	3.94	5.40	4.28	4.35	0.65	14.95
E	9.99	11.28	11.58	12.11	10.97	11.19	0.79	7.06
G	4.08	4.11	3.75	4.46	3.89	4.06	0.27	6.61
T	2.88	2.99	3.27	3.38	2.88	3.08	0.23	7.51
S	2.99	3.29	3.13	3.83	3.25	3.30	0.32	9.69
D	8.31	8.00	7.38	8.49	7.44	7.92	0.50	6.33
TOTAL	73.37	73.42	74.62	93.20	71.41	77.20	9.02	11.68

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214

215 **TABLE 2:** Levels of metals in the samples

SAMPLES	Pb	Cd	Mg	Mn	Fe
concentration(ppm)					
<i>Cucurbita pepo</i>	0.0229±0.004	0.003±0.001	1.0871±0.002	0.0557±0.001	0.7997±0.003
<i>Vitex doniana</i>	0.0302±0.002	0.0036±0.001	1.1371±0.010	0.0499±0.001	1.0799±0.100
<i>Hibiscus cannabinus</i>	0.0396±0.021	0.029±0.001	1.1255±0.004	0.0653±0.004	0.9159±0.012
<i>Letadenia hastata</i>	0.0021±0.001	0.037±0.010	0.9951±0.010	0.1331±0.000	2.2231±0.900
<i>Balanites aegyptiaca</i>	0.0552±0.012	0.041±0.001	1.0753±0.002	0.0405±0.001	0.7723±0.123
permissible levels	0.10	0.05	-	-	-

216 Values represent means of triplicate determination± SD

217 Source for permissible limits: FAO (Mg/L) recommended maximum Concentration of trace elements
218 for vegetables (1985).

219

220 **TABLE 3:** Phytochemical content of the samples

SAMPLES	Tannins (%)	Oxalate (mg/100g)	Phytate (mg/100g)	Saponins (%)	Cyanogenic Glycosides (mg/100g)	Alkaloids (%)	Flavonoids (%)
<i>Cucurbita pepo</i>	0.53±.012	0.60±0.20	1.70±0.01	12.49±1.20	7.59±1.20	17.45±2.51	13.72±1.21
<i>Vitex doniana</i>	0.60±0.12	0.14±0.01	2.10±0.21	15.13±1.50	5.33±1.11	19.37±1.23	14.71±2.30
<i>Hibiscus cannabinus</i>	0.59±0.13	0.32±0.12	3.14±0.12	13.35±2.35	4.93±2.13	17.10±2.50	10.38±1.30
<i>Letadenia hastate</i>	0.55±0.21	0.22±0.03	4.10±0.01	11.85±1.85	6.21±1.20	16.22±1.61	13.22±1.23
<i>Balanites aegyptiaca</i>	0.51±0.13	0.31±0.01	3.08±0.02	13.48±3.12	4.82±1.30	18.13±2.31	9.87±1.32

221 The values represent the mean of three determinations± SD.

222

223 **CONCLUSION AND CONTRIBUTION TO KNOWLEDGE**

224 From these results, leaves of the vegetables constitute rich sources of amino acids and mineral
225 elements. The vegetables are therefore rich alternatives (and/or supplements) which can replenish
226 the cellular requirements of the nutrients. Also, samples contain antinutritional factors such as
227 oxalates and phytates but at low levels. The content of flavonoids and alkaloids in appreciable
228 amounts in the samples is critical given the therapeutic/medicinal use of phytochemicals. Hence, leafy
229 vegetables could contribute to the alleviation of protein malnutrition and micronutrient deficiencies if
230 consumed.

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