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## NUTRIENT AND BIOACTIVE PHYTOCHEMICAL COMPOSITIONS OF Cnidoscolus aconitifolius

Ifeanacho Mercy O., Ikewuchi Catherine C. and Ikewuchi, Jude C.\*

Department of Biochemistry, Faculty of Science, University of Port Harcourt, P.M.B. 5323, Port Harcourt, Nigeria

\*Corresponding Author: ecoli240733@yahoo.com

Abstract

#### History

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Keywords:

Amino acid profile, carotenoids, Cnidoscolus aconitifolius, glycosides, minerals nutrients, phytosterols, vitamins Cnidoscolus aconitifolius is consumed as a vegetable in many parts of Southern Nigeria. Presently, there is no information regarding the allicins alkaloids, carotenoids, glycosides, phytosterols, saponins and terpenoids profiles of the leaves and stems of this vegetable. The proximate, minerals, vitamins, amino acid, carotenoids, saponins, glycosides, phytosterols, terpenoids, alkaloids and allicins profiles of the leaves and stems of *Cnidoscolus aconitifolius* were determined using standard methods. The leaves and stems had high fibre (14.0 - 15.2 g/100g), carbohydrate (40.2 - 41.2 g/100g) and protein (22.2 - 24.5 g/100g). These were equivalent to about 56.0-66.9% daily value for fibre, 44.4-49.0% daily value protein and 13.4-15.1% daily value carbohydrate. They had high contents of selenium, copper, manganese, iron, cobalt, magnesium (leaves only) and vitamins E, B9, C and K (stems only), carotenoids, saponins and glycosides; and moderate phytosterols and terpenoids. Their proteins were rich in essential amino acids (42.7-45.6%). Ten known carorenoids were detected in the stems and leaves, consisting mainly of carotene (43.7-46.1%), lutein (20.8-22.5%) and neo-xanthin (10.92-12.99%). Sapogenin (62.99-64.56%) and saponine (24.5-28. 9%) were the most abundant of the eleven saponins detected. Of the twelve known glycosides were detected, artemetin (65.8-67.6%) and digitoxin (24.8-27.7%) were the most abundant. Seven phytosterols were detected, and consisted mainly of sitosterol (63.6-71.3%), stigmasterol (10.9-13.6%) and 5-avenasterol (10.6-11.4%). Beta-amyrin (52.2-66.3%), alpha-amyrin (18.5-31.6%) and lupeol (14.8-15.9%) were the most abundant of the five phytosterols detected. This result indicates that the leaves and stems of Cnidoscolus aconitifolius are good sources of nutrients and bioactive phytochenicals that can support human health and nutrition. This rich profile makes them potential sources of nutraceuticals.

#### INTRODUCTION

*Cnidoscolus aconitifolius* (Euphorbiaceae), commonly called "hospital too far", "treadsoftly" or tree spinach (English), "Chaya" (Mexico), "Efo Iyana Ipaja" or "Efo Jerusalem" (Yoruba), is consumed as a vegetable in many parts of Southern Nigeria [1, 2]. Its shoot and leaves are employed traditionally to enhance memory, stimulate lactation, strengthen fingernail, darken grey hair, as well as treat acne, alcoholism, anaemia, diabetes, eye problems, fever, gastrointestinal disorders, hypertension, inflammation, insomnia, kidney stones, malaria, nasal congestion, obesity, scorpion stings and varicose veins [1, 2, 3, 4, 5].

The leaves contain bioactive principles such as anthraquinones, cardiac glycosides, phenols, flavonoids, phlobatannin and triterpenoids saponins [5, 6]. GC-MS profiling of the leaf extracts revealed the presence of octadecenoic acid and its esters, n-hexadecanoic acid, n-octadecanoic acid, n-octacosane, 1,2,3-propanetriol and its derivatives, ascorbic acid-2,6dihexadecanoate, borneol, caryophyllene oxide, 4-(1,5-dimethyl hex-4-enyl) cyclohex-2-enone, farnesol and longipinane [1, 5]. Presently, there is no information regarding the allicins alkaloids, carotenoids, glycosides, phytosterols, saponins and terpenoids profiles of the leaves and stems of this vegetable. Therefore, this study investigated the profiles of these compounds in the leaves and stems of *Cnidoscolus aconitifolius*, as well as their nutrient profiles; with a view to providing information on their potential as sources of nutrients and nutraceuticals. It is also intended to provide an overview of their potential contributions to the human diet, as well as the pharmacological significance of some of the bioactive constituents.

#### MATERIALS AND METHODS

#### Materials

Fresh samples of the leaves and stems of Cnidoscolus aconitifolius were collected from a house garden in Aluu community in Rivers State, Nigeria. They were identified (voucher number: UPH/V/1332) by Dr. Chimezie Ekeke at the Herbarium of the Department of Plant Science and Biotechnology, University of Port Harcourt, Port Harcourt, Nigeria. The chemicals used for the assays were of analytical grade and procured from Sigma-Aldrich Co. and Lynnchem Biological Technology Co. The atomic absorption spectrophotometer was a SensAA (GBC Scientific Equipment, USA); while the gas chromatograph was a Hewlett Packard HP 6890 (fitted with flame ionization detector or pulse flame photometric detector) powered with HP Chemstation Rev. A09.01 (1206) software.

#### Methods

#### **Proximate analysis**

The proximate components were determined in triplicates. The moisture content was determined by AOAC Official Method 967.03 [7], ash by AOAC Official Method 942.05 [7], total lipid by AOAC Official Method 920.39 [7], fibre by AOAC Official Method 973.18 [7], and crude protein (% total nitrogen x 6.25) by AOAC Official Method 2001.11 [7]. Carbohydrate was determined by difference (i.e. by subtracting the sum of all the other components from 100 g). The caloric values were calculated with the Atwater factors 4, 9 and 4 for protein, fat and carbohydrate respectively [8].

#### **Determination of vitamin profile**

The vitamin profiles were analysed by a combination of AOAC Official Methods 992.03, 992.04 and 992.26 [7]. Chromatographic conditions were similar to that reported by Ikewuchi et al. [8], except for the use of HP 5 column, and compressed air pressure of 241.32 kPa.

#### Determination of mineral elements and phosphorus composition

Analysis of the mineral elements was carried out according to FAO fertilizer and plant nutrition bulletin 19 [9]. Phosphorus was determined by vanadium molybdate method [9].

#### Determination of per cent daily value

By comparing to daily values [10], per cent daily values were calculated, as follows:

Percent daily value (%)	
weight of particular nutrient in 100g of sample	100
ailv value	100

#### Amino acid analysis

The extraction and analysis were carried out following the methods of AOAC Method 982.30(a,b,c) [7] and Obreshkova et al. [11]. The gas chromatograph was fitted with a pulse flame photometric detector. A split injection (split ratio: 20:1) was adopted, with hydrogen as carrier gas, at flow rate of 1.0 mL/min. An EZ column (10 m x 0.2 mm i.d. x 0.25 µm film thickness), was used. The inlet and detector temperatures were 250 and 320 °C. The hydrogen and compressed air pressure were 137.90 and

241.32 kPa. The oven was programmed initially at 110 °C, ramped at 7 °C/min to 320 °C; and kept at 320 °C for 5 min.

#### Evaluating digestible indispensable amino acid (DIAA) reference ratio and DIAA score

The digestible indispensable amino acid (DIAA) reference ratio for each indispensable amino acid (IAA) in the test proteins were determined by comparing their amino acid composition, with WHO reference protein patterns [12], according to the following equation.

> DIAA reference ratio mg of a DIAA in 1g protein of the sample mg of the same DIAA in 1g of reference protein

The DIAA with the least DIAA reference ratio became the limiting amino acid; while its ratio was converted to percentage, to obtain the digestible IAA score (DIAAS) [12].

#### **Determination of the phytochemical constituents**

#### **General procedures**

The preparation of the standard solutions, as well as the identification and quantification of the component compounds were as earlier reported by Ikewuchi et al. [8].

#### Determination of alkaloids, allicins, carotenoids, glycosides and saponins compositions

The alkaloids were extracted in accordance with Ngounou et al. [13]; allicins according to Chehregani et al. [14]; carotenoids according to Takagi [15]; glycosides according to Oluwaniyi and Ibiyemi [16]; and saponins in line with Guo et al. [17]. The extracts were subjected to gas chromatography under similar conditions as reported by Ikewuchi et al. [8].

#### **Determination of sterols composition**

Extraction of oil was carried out according to AOAC Official method 999.02 [7], while analysis of sterols was carried out according to AOAC Official methods 994.10 and 970.51 [7]. The sterol fraction was then subjected to gas chromatography with similar conditions as reported by Ifeanacho et al. [18].

#### Derivation of compositions per dry weight from the composition per wet weight

Compositions per dry weight of the parameters were derived from compositions per wet weight and vice versa, using the following formula [19].

Composition per dry weight (%)  $= \frac{Composition \ per \ wet \ weight \ (\%) \times 100}{Composition \ per \ wet \ weight \ (\%) \times 100}$ Drv matter content (%)

#### **RESULTS AND DISCUSSION**

The proximate composition and nutrient potential of the leaves and stems of Cnidoscolus aconitifolius is shown in Table 1. They had high protein and fibre, and moderate carbohydrate contents. In comparison to relevant daily values [10], a 100g serving of the leaves can provide about 56.0-60.3% of daily value for crude fibre, 13.4-14.4% of daily value for carbohydrate, 15.0-16.1% of daily value for caloric value, 6.9-7.5% of daily value for total lipid and 49.0-52.8% of daily value for crude protein. A 100g serving

of the stems can provide 60.8-66.9% of daily value for crude fibre, 60.8-66.9% of daily value for carbohydrate, 14.3-15.7% of daily value for caloric value, 5.4-5.9% of daily value for total lipid and 44.4-48.8% of daily value for crude protein.

**Table 1.** Proximate composition and nutrient potential of the leaves and stems of *Cnidoscolus aconitifolius*

	(	Compositio	on (g/100g	Potential (per cent daily value/100g)				
Component	Leaf		Stem		Leaf		Stem	
	Fresh	Dry	Fresh	Dry	Fresh	Dry	Fresh	Dry
Moisture	7.20	0.00	9.10	0.00	NA	NA	NA	NA
Dry matter	92.80	100.00	90.90	100.00	NA	NA	NA	NA
Ash	9.60	10.34	8.80	9.68	NA	NA	NA	NA
Crude protein	24.50	26.40	22.20	24.42	49.00	52.80	44.40	48.85
Crude fat	4.50	4.85	3.50	3.85	6.92	7.46	5.39	5.92
Crude fibre	14.00	15.09	15.20	16.72	56.00	60.35	60.80	66.89
Total carbohydrate	40.20	43.32	41.20	45.32	13.40	14.44	13.73	15.11
Caloric value	299 30	322.52	285 10	313 64	14 97	16.13	14 26	15.68

Values are means of triplicate determinations. <sup>‡</sup>The unit of caloric value = kcal/100g; NA = not applicable

The leaves and stems had low moisture levels. This is good for their "keeping" quality, because high moisture increases water activity and probability of microbial growth [20]. They had higher proteins than amaranth, cabbage, green and red lettuce [21, 22, 23, 24], *Pandiaka heudelotii* [8], *Tridax procumbens* [25], barley, maize and wheat, and are comparable to bean [26, 27]. They can be considered to be good protein sources, since they have greater proteins than the WHO 10% cut-off [12]. They had higher lipid, carbohydrate, ash and caloric value than *T. procumbens* [25], amaranth, cabbage, green and red lettuce [21 - 24]. They also had higher fibre than *P. heudelotii* [8], *T. procumbens* [25], cabbage, green and red lettuce [21 - 23]. Therefore, consuming them amounts to high fibre intake, which has been reported to enhance bowel clearance and modulate blood cholesterol, glucose and insulin responses [28].

 
 Table 2. Mineral elements composition and nutrient potential of leaves and stems of *Cnidoscolus aconitifolius*

Mineral nutrient	Mineral Composition (mg/kg) Potenti nutrient					otential (%	ial (% daily value/100g)			
	Leaf		Stem		Le	af	5	Stem		
	Fresh	Dry	Fresh	Dry	Fresh	Dry	Fresh	Dry		
Sodium	366.73	395.1 8	1347.8 0	1482. 72	1.53	1.65	5.62	6.18		
Calcium	2461.65	2652. 64	1963.0 9	2159. 62	24.62	26.53	19.63	21.60		
Magnesium	4827.22	5201. 74	824.19	906.7 0	120.68	130.04	20.61	22.67		
Potassium	6975.55	7516. 76	3585.5 5	3944. 50	19.93	21.48	10.24	11.27		
Phosphorus	984.35	1060. 72	1436.7 9	1580. 62	9.84	10.61	14.37	15.81		
Selenium	0.16	0.18	0.19	0.21	23457. 10	25277. 10	26757.1 0	29435.80		
Cobalt	0.01	0.02	0.10	0.11	23333. 33	25000. 00	160000. 00	1/6666.67		
Copper	14.48	15.60	0.46	13.83	72.38	/8.00	62.87	52.06		
Iron	92.16	99.31	86.90	95.60	51.20	55 17	47.52	53.11		
Sodium/	0.05	0.05	0.38	0.38	NA	NA	-10.20 NA	NA		
potassium ratio <sup>‡</sup>										
Calcium/ phosphorus ratio <sup>‡</sup>	2.50	2.50	1.37	1.37	NA	NA	NA	NA		

The leaves and stems of *C. aconitifolius* had high copper, iron, manganese, selenium and magnesium (moderate in stems) (**Table 2**). A comparison to relevant daily values [10], shows that a 100g serving of the leaves and stems are respectively equivalent to 87.1 - 93.9% and 47.3-52.1% daily value for manganese; 23457.1-25277.1% and 26757.1-29435.8% daily value for selenium; and 72.4-78.0% and 62.9-69.2% daily value for copper. It is also equivalent to 120.7-130.0% and 20.6-22.7% daily value for magnesium; 51.2-55.2% and 48.3-53.1% daily value for iron; 24.6-26.5% and 19.6-21.6% daily value for calcium; 19.9-21.5% and 10.2-11.3% daily value for potassium; 9.8-10.6% and 14.4-15.8% daily value for phosphorus; and 1.5-1.7% and 5.2-6.2% daily value for calcium.

The leaves and stems had higher calcium, copper, iron, magnesium, manganese, phosphorus and selenium than amaranth, cabbage, green and red lettuce [21 - 24]. According to Korkmaz et al. [29], magnesium is a calcium channel blocker, and is involved in many different metabolic processes, including maintenance of cell membrane function, modulation of smooth muscle contraction and enzymatic activities. They further stated that magnesium is a neuroprotective agent; increases blood flow to tissues; plays a vital role in development and function of the eye; and in diabetic patients, decreases insulin resistance, enhances glycaemic control and prevents diabetic retinopathy [29]. Manganese functions both as a cofactor and activator to a large number of manganesedependent enzymes, including arginase, decarboxylases, dehydrogenases, DNA and RNA polymerases, glutamine manganese synthetase, kinases, superoxide dismutase, neurotransmitter synthetic enzymes, oxidases and sugar transferases [30, 31, 32]. It is an integral part of certain metalloproteins [30, 32]; participates in the metabolism of biogenic amines and regulation of carbohydrate metabolism [30, 33). The leaves and stems had high calcium to phosphorus ratios. High dietary calcium/phosphorus ratio has a positive influence on bone mass [34]; and allows for strong bone development because absorption of calcium under this condition is maximal [35, 36].

The leaves and stems had higher potassium than *T*. *procumbens* [37], amaranth (leaves only), cabbage, green and red lettuce [21 - 24]. They had low sodium to potassium ratios ( $\leq$  1.67), and so, may be very safe for consumption by hypertensive individuals [38].

The leaves and stems had high vitamins E, B9, C and K (stems only) levels (Table 3). They had lower vitamins A and B3 than amaranth leaves, cabbage, green and red lettuce [21 - 24]. The vitamin B6 content of the stems was lower than that of amaranth [24], but higher than T. procumbens [39], cabbage, green and red lettuce [21 - 23]; while that of the leaves was lower than all of them. The leaves and stems had higher vitamins B2 and C than T. procumbens [39], amaranth, cabbage, green and red lettuce [21 - 24, 40]. They can respectively provide, per 100g serving, 76.3% and 100.3% of the daily value for vitamin C; as well as 14.9% and 18.5% of daily value for vitamin B2. The vitamin B1 content of the leaves was higher than T. procumbens [39], amaranth, cabbage, green and red lettuce [21 - 24]; while that of the stems was lower. The leaves can provide about 29.7% of the daily value for vitamin B1, per 100g serving. The stems had higher vitamins B5 and E than cabbage, green and red lettuce [21 - 23]; while leaves had lower values. They can respectively provide, per 100g serving, 141.0% and 7234.9% of daily value for vitamin E. Vitamin E is an anticoagulant, antiviral, immunemodulatory and neuroprotective agent [41].

The leaves and stems had higher vitamin B9 than *T. procumbens* [39], amaranth (leaves only), cabbage, green and red lettuce [21 - 24]. They can both provide 119.5% and 10.9% of the daily value for vitamin B9, respectively per 100g serving. The vitamin K content of the stems was higher than those of cabbage, but lower than those of amaranth, green and red lettuce [21 - 24]. That of the leaves was lower than all of them. They can respectively provide 13.9% and 155.8% of the daily value for vitamin K, per 100g serving.

**Table 3.** Vitamins composition and potential of the leaves and stems of

 *Cnidoscolus aconitifolius*

		Leaves			Stems	
	Retention time (min)	Composition (mg/kg)	Per cent daily value/100 g	Retention time (min)	Composition (mg/kg)	Per cent daily value/ 100 g
Vit. B3	12.366	0.802	0.401	12.373	2.282	1.141
Vit. B6	13.744	0.004	0.018	13.742	1.763	8.815
Vit.	16.044	457.965	76.328	16.036	601.631	100.272
Vit.	17.368	0.217	1.445	17.365	0.220	1.467
Vit. B1	18.060	4.455	29.697	18.053	0.051	0.340
Vit. B2	18.596	2.532	14.893	18.590	3.152	18.541
Vit. E	19.526	0.127	141.023	19.518	6.512	7234.870
Vit. B9	20.542	4.779	119.470	20.536	0.435	10.868
Vit. K	21.825	0.112	13.947	21.820	1.246	155.810
Vit. B5	22.606	0.037	0.037	22.600	2.791	2.791

The amino acid profile and DIAA reference ratios of proteins from the leaves and stems of C. aconitifolius are given in Tables 4 and 5, respectively. They are rich in essential amino acids, 45.6% for the leaves and 42.7% for the stems [especially histidine, valine, threonine, isoleucine, phenylalanine and tyrosine, lysine (leaves only) and tryptophan (stems only)] and can meet the daily requirements [12] for these essential amino acids. Compared to WHO reference protein patterns for infant (birth to 6 months), child (6 months to 3 years) and older child, adolescent, adult [12], the DIAA scores of the leaf protein were 46.60 (with tryptophan as the limiting amino acid), 75.07 and 88.13 (with methionine and cysteine as the limiting amino acid) respectively. Those of the stem protein were 49.38, 59.78 and 70.99, with lysine as the limiting amino acid. Every 100 g of these leaf and stems proteins contained, respectively, 42.54 g and 36.79 g of essential amino acids, 2.03 g and 2.12 g of sulphur-containing amino acids and 7.86 g and 8.26 g of aromatic amino acids (Table 6). The leaf and stem proteins can be used for the supplementation of histidine, valine, threonine, isoleucine, phenylalanine and tyrosine in all the age groups; tryptophan and lysine in the diets of children (6 months and above), adolescents and adults. Compared to child (6 months to 3 years) requirement protein pattern [12], proteins from the leaves and stems of C. aconitifolius had higher DIAA scores, than cooked peas, cooked kidney beans, cooked rice, cooked rolled oats, wheat bran, roasted peanuts and rice protein concentrate [42].

The leaves and stems had high carotenoids, saponins and glycosides, moderate phytosterols and terpenoids, and low allicins and alkaloids. Ten known carorenoids were detected in them (**Table 6**), made up of carotene (leaves: 46.12%; stems: 43.70%), lutein (leaves: 22.45%; stems: 20.75%), neoxanthin (leaves: 10.92%; stems: 12.99%), xanthophyll (leaves: 7.91%; stems: 7.48%), violaxanthin (leaves: 6.13%; stems: 6.27%), antheraxanthin (leaves: 4.91%; stems: 7.26%), astaxanthin (leaves: 1.53; stems: 1.55%). The other compounds made up less than 0.01%. The leaves and stems had higher carotene and lutein than *T. procumbens* [19], cabbage, green and red lettuce [21 - 23]. They had higher anthera-xanthin, neoxanthin and viola-xanthin than *T. procumbens* [19]. Their lycopene and malvidin contents were higher than cabbage, green and red lettuce [21 - 23].

Carotenes possess anticancer, antioxidant, immunemodulatory, photo-protective and pro-vitamin A properties [43, 44]. Studies have shown that consuming lutein reduces the risk of age-related macular degeneration, cancers, cardiovascular disease and cataract [43, 45]. Lutein also has antioxidant and photoprotective properties [41, 45, 46]. Astaxanthin exhibits healthpromoting effects such as anti-cancers, anti-dermatitis, antidiabetic, antihypertensive, anti-inflammatory, anti-obesity, antioxidant, cardioprotective, gastroprotective, hepato-protective, hypolipidaemic, immune-modulatory, neuroprotective, nephroprotective and ocular-protective activities [43, 45, 47, 48]. Antheraxanthin is an antioxidant [49]; while violaxanthin and neoxanthin has antioxidant and anti-proliferative activities [45 -47, 49].

Eleven known saponins were detected in the leaves and stems (**Table 6**), mainly made up of sapogenin (leaves: 62.99%; stems: 64.56%), saponine (leaves: 28. 91%; stems: 24.54%), neochlorogenin (leaves: 8.10%; stems: 10.90%). Twelve known glycosides were detected (**Table 6**), consisting mainly of artemetin (leaves: 65.77%; stems: 67.56%), digitoxin (leaves: 27.65%; stems: 24.81), digoxin (leaves: 5.87%; stems: 6.77%) and cucurbitacin (leaves: 0.68%; stems: 0.55%).

This study showed the artemetin content of *C. aconitifolius* leaves to be comparable to *Artemisia annua* [50]. Artemetin possesses anti-inflammatory, antioxidant, antihypertensive, cardio-protective, immune-modulatory, cell cycle and lipoxygenase inhibitory properties [51, 52, 53, 54]. Digitoxin and digoxin are used in managing atrial fibrillation, congestive cardiac insufficiency, congestive heart failure and cardiac arrhythmias [55, 56]. These promising anticancer agents inhibit Na<sup>+</sup>/K<sup>+</sup>-ATPase and increase intracellular sodium ions [55, 56]. Cucurbitacins are adaptogenic, anti-atherosclerotic, anti-diabetic, anti-inflammatory, antimicrobial, antioxidant, antitumor, hepatoprotective and immune-modulatory agents [57].

In the leaves and stems of *C. aconitifolius* (**Table 7**), seven known phytosterols were detected, including sitosterol (leaves: 63.64%; stems: 71.28%), stigmasterol (leaves: 13.60%; stems: 10.92%), campesterol (leaves: 12.13%; stems: 6.36%) and 5-avenasterol (leaves: 10.61%; stems: 11.42%). The leaves and stems had lower phytosterol than cabbage and lettuce [21, 58]. They had lower sitosterol than cabbage, but higher contents than lettuce and *T. procumbens* [19, 58]. Their stigmasterol contents than lettuce [58]. They also had higher avenasterol than lettuce [58].

Beta-sitosterol possesses analgesic/anti-nociceptive, angiogenic, anthelmintic, anti-atherosclerosis, anti-arthritic, anticancer, anti-diabetic, anti-hyperlipidaemic, anti-inflammatory, antimicrobial, antioxidant, antipyretic and immunomodulatory activities [8, 59, 60]. According Ikewuchi *et al.* [8] and Saeidnia *et al.* [61], stigmasterol has analgesic, anticonvulsant, anti-hypercholesterolemic, anti-inflammatory, anti-osteoarthritic,

antioxidant, antitumor, hypoglycaemic and memory enhancing activities. Campesterol exhibits anticancer, anti-inflammatory and anti-hypercholesterolemic properties [59, 62]. The antioxidant effect of avenasterols has been reported [63].

Table 4. The amino acids composition of the leaves and stems of Cnidoscolus aconitifolius

Compound	Leaves				Stems			
	Retention	Composi	tion		Retention	Composition		
	time (min)	g/100g	g/100g sa	ample	time (min)	g/100g	g/100g sa	ample
		protein	Fresh	Dry	_	protein	Fresh	Dry
Glycine	8.903	5.698	1.244	1.341	8.652	5.078	1.127	1.240
Alanine	10.646	5.936	1.070	1.153	10.180	4.365	0.969	1.066
Serine	12.098	4.537	0.986	1.062	12.098	4.022	0.893	0.982
Proline	13.740	5.589	1.226	1.321	13.740	5.002	1.110	1.222
Valine*	14.697	5.922	1.251	1.348	14.697	5.107	1.134	1.247
Threonine*	16.040	4.700	1.069	1.152	16.040	4.364	0.969	1.066
Isoleucine*	18.057	4.505	1.182	1.274	16.602	4.826	1.071	1.179
Leucine*	19.027	6.095	1.204	1.297	18.057	4.912	1.091	1.200
Aspartate	19.522	9.100	1.328	1.431	19.522	5.419	1.203	1.324
Lysine*	20.594	6.618	0.835	0.900	21.099	3.408	0.757	0.832
Methionine*	21.674	1.560	0.246	0.265	21.823	1.005	0.223	0.245
Glutamate	22.605	14.601	4.267	4.598	22.605	17.416	3.866	4.253
Phenylalanine*	23.232	5.420	1.193	1.285	23.232	4.868	1.081	1.189
Histidine*	23.968	4.804	0.946	1.019	23.968	3.861	0.857	0.943
Arginine	25.109	5.370	1.985	2.139	24.878	8.100	1.798	1.978
Tyrosine*	25.757	1.651	0.543	0.585	25.616	2.214	0.492	0.541
Tryptophan*	26.250	0.792	0.288	0.310	26.250	1.175	0.261	0.287
Cysteine*	27.114	0.467	0.273	0.295	26.830	1.116	0.248	0.273
Total amino acid content		93.369	21.133	22.773		86.261	19.149	21.067
Total essential amino acids		42.536	9.030	9.730		36.856	8.182	9.001
Total nonessential amino acids		50.833	12.104	13.043		49.403	10.967	12.065
Total sulphur containing amino acids		2.027	0.520	0.560		2.121	0.471	0.518
Total aromatic amino acids		7.864	2.023	2.180		8.258	1.833	2.017

\*Essential amino acids

Table 5. Digestible indispensable amino acid (IAA) reference ratios of proteins from the leaves and stems of Cnidoscolus aconitifolius

Amino acids	Ami	no acid	Digestible Indispensable Amino Acid (IAA) reference ratio						
	compos	ition from	Comparis	on to Infant (birth	Comparison to Child (6		Comparison to older child,		
	prese	nt study	to 6 mon	ths) requirement	month	s to 3 year)	adolescent, adult		
	(mg/g	protein)	pro	tein pattern	requiremen	requirement protein pattern		requirement protein pattern	
	Leaves	Stems	Leaves	Stems	Leaves	Stems	Leaves	Stems	
Histidine	48.045	38.609	2.288	1.839	2.402	1.931	3.003	2.413	
Isoleucine	45.055	48.258	0.819	0.877	1.408	1.508	1.502	1.609	
Leucine	60.954	49.122	0.635	0.512	0.924	0.744	0.999	0.805	
Lysine	66.182	34.075	0.959	0.494	1.161	0.598	1.379	0.710	
Methionine + cysteine	20.270	21.208	0.614	0.643	0.751	0.786	0.881	0.922	
Phenylalanine + tyrosine	70.713	70.828	0.752	0.754	1.360	1.362	1.725	1.728	
Threonine	46.998	43.642	1.068	0.992	1.516	1.408	1.880	1.746	
Tryptophan	7.921	11.753	0.466	0.691	0.932	1.383	1.200	1.781	
Valine	59.222	51.067	1.077	0.929	1.377	1.188	1.481	1.277	

Compound		Leaves			Stems	
	Retention	Compositi	on (mg/kg)	Retention	Compositio	on (mg/kg)
	time (min)	Fresh	Dry	_ time (min)	Fresh	Dry
Carotenoids						
Malvidin	19.164	0.0006215	0.0006697	19.166	0.0000683	0.0000751
Beta-cryptoxanthin	20.532	0.0992480	0.1069483	20.535	0.0109350	0.0120297
Lycopene	21.498	0.0000266	0.0000287	21.501	0.0000305	0.0000336
Carotene	22.688	201.0858000	216.6872845	22.688	236.6788000	260.3727173
Lutein	23.228	97.9037000	105.4996767	23.23	112.3721000	123.6216722
Xanthophyll	24.031	34.5080000	37.1853448	24.033	40.5110000	44.5665567
Antheraxanthin	24.876	21.4285000	23.0910560	24.882	39.3176000	43.2536854
Astaxanthin	25.610	6.6838500	7.2024246	25.615	8.3725000	9.2106711
Violaxanthin	26.354	26.7323000	28.8063578	26.355	33.9565000	37.3558856
Neoxanthin	27.164	47.6049000	51.2983836	27.219	70.3723000	77.4172717
Total carotenoids content		541.6908000	469.8781747		436.0470000	595.8105982
Saponins						
Hispigenin	17.547	0.0019419	0.0020926	17.663	0.0007830	0.0008614
Solagenin	18.836	0.0053929	0.0058113	18.759	0.0016800	0.0018482
Diosgenin	19.516	0.0007216	0.0007775	19.514	0.0004930	0.0005424
Tigogenin	19.962	0.0018753	0.0020208	19.954	0.0012800	0.0014081
Neochlorogenin	20.471	26.2613000	28.2988147	20.469	11.9754000	13.1742574
Hecogenin	21.820	0.0004445	0.0004790	21.815	0.0002420	0.0002662
Sapogenin	22.599	204.2939000	220.1442888	22.595	70.9351000	78.0364136
Tribuloin	23.231	0.0043084	0.0046427	23.226	0.0015270	0.0016799
Yanogenin	23.967	0.0043724	0.0047116	23.963	0.0018650	0.0020517
Conyzorgin	24.790	0.0067344	0.0072569	24.786	0.0000432	0.0000475
Saponine	26.355	93.7481000	101.0216595	26.282	26.9639000	29.6632563
Total saponins content		324.3225000	349.4925554		109.8823000	120.8826328
Glycosides						
Arbutin	17.772	0.0147251	0.0158676	17.774	0.0189130	0.0208064
Linamarin	18.054	0.0000005	0.0000006	18.056	0.0000007	0.000008
Salicin	18.842	0.0015738	0.0016959	18.844	0.0032170	0.0035391
Artemetin	19.103	114 089400	122.9411638	19,105	65.2432000	71,7746975
Amvedalin	19 520	0.0018822	0.0020283	19.522	0.2378190	0.2616271
Ouabain	20.469	0.0214212	0.0230832	20.471	0.0271170	0.0298317
Dhurrin	21 327	0.0011040	0.0011897	21 103	0.0010690	0.0011760
Prunasin	21.627	0.0007409	0.0007984	21.439	0.0009370	0.0010308
Cucurbitacin	21.821	1 1756200	1 2668319	21 909	0.5301180	0 5831881
Digitaxin	22.066	47 9701000	51 6919181	22.068	23 9585000	26 3569857
Digoxin	22.000	10.1820000	10 9719828	22.604	6 5343700	7.1885259
Lotaustralin	22.002	0.00776349	0.0083653	22.004	0.0094160	0.0103586
Total alveosides content	23.700	173 4663000	186 9249260	25.700	96 56/7000	106 2317675
Digitoxin Digoxin Lotaustralin Total glycosides content	22.066 22.602 23.966	47.9701000 10.1820000 0.00776349 173.4663000	51.6919181 10.9719828 0.0083653 186.9249260	22.068 22.604 23.968	23.9585000 6.5343700 0.0094160 96.5647000	26.3 7.18 0.01 106.2

# Table 6. Composition of carotenoids, saponins and glycosides isolated and detected in the leaves and stems of Cnidoscolus aconitifolius

### Table 7. Composition of alkaloids isolated and detected in leaves and stems of Cnidoscolus aconitifolius

Interm (mm)Interm (mm)Composition (pr/kg) (mm)Recention time (mm)Composition (pr/kg) (mm)Recention time (mm)Composition (pr/kg)Trigonelline7.2280.00710.7330.00590.0061Augustifiline7.2230.00500.00777.2350.01600.0193Sparetine9.0210.02550.02759.3200.01140.0125Discorrine9.2250.01160.01259.7420.01630.0173Discorrine9.2250.0160.01251.42591.43501.4350Disportine1.03411.80261.472591.03523.84106.2497Disportine1.03410.01600.017311.0440.01640.0171Disportine1.13510.01710.1241.13520.01490.014Zeatin1.20960.03110.02580.027813.4170.0160.0117Disportine1.34190.01280.027813.4170.0160.01170.181Oxasoanine1.53710.03810.01111.53400.0190.113Oxasoanine1.53720.03810.01111.53800.0190.132Oxasoanine1.53720.03810.01111.54400.0190.132Oxasoanine1.53720.03810.01311.5410.01620.0132Oxasoanine1.53720.03810.01311.5410.01620.0132Orasoanine1.53720.0371 <th>Compound</th> <th></th> <th>Leaves</th> <th></th> <th colspan="2">Stems</th> <th></th>	Compound		Leaves		Stems		
Imm         Fresh         Dry         Imm         Fresh         Dry           Trigenelline         7.528         0.0071         0.0077         7.533         0.0189         0.0089           Sparfelne         9.900         0.0550         0.0184         8.088         0.0166         0.0183           Ellipcine         9.321         0.0255         0.0225         9.220         0.0114         0.0125           Discourine         9.925         0.0116         0.0235         0.722         0.0108         0.0071           Scrotnin         10.324         2.847         3.1086         10.335         1.2200         1.3520           Lapatize         10.846         13.0276         11.7550         10.857         0.0071           Dhydroxordnetize         11.352         0.0171         0.0126         0.0171         0.0149         0.0044           Scrotnin         1.052         0.831         0.0356         12.044         0.0149         0.0144           Vicine         1.3419         0.0128         0.0139         12.348         0.0111         0.0149           OrderscorademetryLammanhumine         1.4519         0.0528         0.0214         0.0113         0.012           Dydroxo		Retention time	Compositi	on (µg/kg)	Retention time	Composition	(µg/kg)
Frigmediine         2.528         0.0071         7.513         0.0059         0.0054           Aggastifaline         7.923         0.9063         0.9766         7.925         0.5180         0.5599           Spartelae         8.900         0.0459         0.0454         8.988         0.0166         0.0183           Ellipcine         9.221         0.0255         9.742         0.0163         0.0179           Sectorin         0.323         2.847         3.1086         10.333         1.2200         1.352           Lapanire         10.846         13.026         14.7550         10.852         5.840         6.2071           Dhydrodiscorbide         11.054         0.0101         0.0126         11.352         0.0019         0.0351           Zastin         12.096         0.0311         0.0258         12.094         0.0149         0.014           Vicine         13.419         0.0258         0.0278         13.417         0.0166         0.0117           Dhydrodiscorbine         13.419         0.0258         0.0279         1.4514         0.0184         0.0179           Oxcascorbine         13.419         0.0212         0.0314         0.1630         0.171           Dhy		(min)	Fresh	Dry	(min)	Fresh	Dry
Appendianc7930983097679250.1930.493Sparafac80000.4500.45480800.0140.015Sparafac92000.1140.0259.420.1040.125Discorine9.230.0140.1259.420.1260.125Scanan0.1321.4900.1321.6400.0171.1440.010Dilydrodesca1.0340.0130.0171.0440.0140.014Dilydrodesca1.0340.0130.0151.2440.0140.014Scanan1.2410.0120.0131.2430.0140.014Dilydrodesca1.2410.0120.0131.2430.0140.014Scanan1.2410.0240.0341.2430.0140.014Scanan1.2410.0240.0341.2410.0140.014Scanan1.2410.0240.0341.2410.0140.014Scanan1.2410.0240.0341.2410.0140.014Scanan1.2410.0240.0341.2410.0140.014Scanan1.2410.0240.0341.2410.0140.014Scanan1.2410.0240.0341.2410.0140.014Scanan1.2410.0240.0341.2410.0140.014Scanan1.2410.0240.0240.0240.0240.024Scanan1.2410.0240.024	Trigonelline	7.528	0.0071	0.0077	7.533	0.0059	0.0065
System8,0000,03500,04348,0980,01690,0169Bilgenine0,2520,02150,2320,0140,013Dissortine10,232,8473,1080,3331,2091,332Lapanine10,440,0160,1731,8220,0190,0140,0140,015DiApladyerbonhfaine10,240,0170,1231,3320,0190,0130,0140,	Augustifoline	7.923	0.9063	0.9766	7.925	0.5180	0.5699
Elipcine9.310.0250.0179.300.0140.012Discordin9.0240.0130.0230.013	Sparteine	8.900	0.0450	0.0484	8.908	0.0166	0.0183
Descrine9.9250.0160.01259.720.01630.0173Strotonin10.3402.8473.10840.3331.22011.321Lapanice0.8463.62700.01331.0430.00510.0171Dhydrochonhifoline1.1040.01600.01311.03240.00940.0141Carln1.2300.01710.01241.0440.01410.0141Scharcananike1.2810.0120.01311.2960.01140.0141Dilydro-ox-denchoxytamantamine1.4110.02840.02741.4160.01610.1181Okosonnine1.5290.02140.03141.5340.01940.1181Chrohonine1.5270.0210.3141.5490.01940.1282Chrohonine1.6270.0220.03141.5680.12940.131Chrohonine1.5470.0420.03141.5840.01641.528Chrohonine1.5470.0430.0311.5840.01641.528Chrohonine1.5480.0420.0311.5840.01640.0164Chrohonine1.5480.0420.0311.5840.01640.0164Chrohonine1.5490.0420.0311.5840.01640.01640.0164Chrohonine1.5490.0420.0311.5840.01640.01640.0164Chrohonine1.5490.0420.01540.01640.01640.01640.0164Chrohonine<	Ellipcine	9.321	0.0255	0.0275	9.320	0.0114	0.0125
Sertonin10.3232.88473.0860.3331.2901.352Lapinine10.641.0260.1731.0440.6200.017DiAlphalydorbankhfile11.520.0170.1261.1320.0490.0181Didgrodioseerine11.520.0170.1321.2420.0190.01910.01810.017Pochadesenande12.820.01290.01391.2430.01810.01210.01910.01810.017Didgro-sox-denetboxyhaemanthamine14.910.0280.2371.4170.0190.01310.01910.0131Chaosanine15.950.0240.0311.5340.0190.01310.01910.0131Chaosanine15.950.0240.0311.5440.0190.0131Chaosanine16.970.0270.0341.6460.9490.162Chaosanine16.970.0320.0341.6461.6470.1621.637Chaosanine16.970.0320.0341.7440.0180.0191.638Chaosanine16.970.0280.0341.7540.0180.0191.639Chaosanine16.970.0280.0341.7540.0180.0191.639Chaosanine16.970.0280.0311.7540.0180.0191.639Chaosanine16.970.0280.0311.7540.0180.0280.018Chaosanine16.970.0280.0280.0311.554<	Dioscorine	9.925	0.0116	0.0125	9.742	0.0163	0.0179
Lapanine10.841.3621.47501.6320.8100.073D'Alpadrofseminfone11.3520.0170.1251.3220.017D'Adrofseconine1.2320.0170.0251.2320.0130.0140S-Catacenanife1.2810.0280.0311.2400.01400.017D'Adrofseconine1.2410.0240.0541.41500.01840.017D'Adrofseconine1.4150.0520.0541.41600.01840.017D'Adrofseconine1.4150.0520.0541.41600.01840.017D'Adrofseconine1.4190.2300.0541.41600.01840.0184Chachodine1.6240.0310.0311.5360.0120.013Chachodine1.6270.0320.0541.6360.0200.012D'Adrofseconine1.6270.0320.0541.6360.0200.012Chachodine1.6270.0320.0541.6360.0400.012D'Adrofseconine1.6270.0531.6370.0540.0540.054D'Adrofseconine1.6270.0531.6470.0540.0540.054D'Adrofseconine1.6360.0420.0541.6470.0540.0540.054D'Adrofseconine1.6490.0420.0541.6470.0540.0540.054D'Adrofseconine1.6490.0540.0571.6470.0540.0540.054D'Adrofseconine <th>Serotonin</th> <th>10.323</th> <th>2.8847</th> <th>3.1086</th> <th>10.353</th> <th>1.2290</th> <th>1.3520</th>	Serotonin	10.323	2.8847	3.1086	10.353	1.2290	1.3520
1-A.plaphydrorhambifaline11.0540.01630.01731.10440.00540.0054Ditydredloscorine1.2040.01340.0351.2040.01340.0149-Catalceenamide1.2010.0120.0350.2040.0130.01340.01349-Catalceenamide1.2010.0120.0350.2031.4100.0160.0117Ditydre-os-demethorybaenamathanine1.4190.2030.2371.4100.0170.137Chaosasanine1.5350.2340.0311.5240.0190.0137Cinchonine1.6370.2380.03541.6360.0190.0137Cinchonine1.6370.0290.03541.6467.29804.0317Cinchonine1.6429.71710.08891.6467.29804.0319Paropian1.7030.0620.0181.7370.0120.012Cinchonine1.7040.0120.0131.7370.0120.013Cinchonine1.7040.0120.0131.7370.0120.013Cinchonine1.7040.0140.0141.7440.0180.021Cinchonine1.7040.0120.0131.7370.0120.014Cinchonine1.7040.0140.0141.7340.0120.014Cinchonine1.7040.0140.0141.7340.0120.014Cinchonine1.7040.0140.0161.7340.0140.014Cinchonine <td< th=""><th>Lupanine</th><th>10.846</th><th>13.6926</th><th>14.7550</th><th>10.852</th><th>5.6810</th><th>6.2497</th></td<>	Lupanine	10.846	13.6926	14.7550	10.852	5.6810	6.2497
Disparodisservine1.1520.0170.01261.1520.04940.0164Zenin12.0960.03310.05512.9460.01310.0149-Octadecenamide13.4190.0280.07813.4170.0100.021Ditycroso-demethoryhaenanthamine14.1510.05420.037414.5190.0140.020Corasosanine15.950.02940.031715.3440.0190.031Conconsine16.370.03810.04116.440.0140.016Crinane-diphool16.420.371710.038416.4670.032Crinane-diphool16.420.371710.038416.4670.032Diphonine16.620.371710.038417.540.0420.031Crinane-diphool16.620.371710.038417.540.0420.031Diphonine16.620.371710.038417.540.0320.032Crinane-diphool16.620.37140.03216.670.031Diphonine17.540.0420.05417.540.0310.054Crinane-diphool18.5210.6817.540.0320.0320.032Diphonine18.920.02345.1518.5516.940.034Corine-diphool18.9210.280.03116.940.0310.032Diphonine18.9210.280.03218.940.0310.0320.031Diphonine18.940.0410.7518.9	13-Alphahydrorhombifoline	11.054	0.0160	0.0173	11.044	0.0065	0.0071
Zeatin12.090.0310.035412.040.01490.01499-Otacenamide12.8210.01290.013912.960.01130.0124Vicine13.4190.02580.027813.170.01600.017Ditydrs-ox-denethoxyhaenanthamine14.190.22080.237914.160.16300.1837Oxossonine15.3570.02140.013115.2440.01910.0131Cinchonina16.470.3210.015416.4630.0120.0132Cinchonina16.4520.3717710.088916.4679.63641.0381Potopine17.0300.0640.103817.0870.0641.0381Potopine17.0300.0640.038417.9870.01240.0143Cinchonina17.0400.0420.034317.3570.01240.0143Potopine17.0300.0640.038417.9870.01240.0141Cinchonina17.9400.0420.034115.480.02940.0294Potopine17.0400.0420.03417.9490.0240.024Cinchoninamine17.9400.0420.0340.0340.03740.0340.034Potopine17.9400.0420.0240.0340.0340.0340.0340.034Cindinine18.0490.0240.0250.0341.9340.0340.0340.034Potopine19.050.0350.0360.0370.0340.034 <th>Dihydrodioscorine</th> <th>11.352</th> <th>0.0117</th> <th>0.0126</th> <th>11.352</th> <th>0.0049</th> <th>0.0054</th>	Dihydrodioscorine	11.352	0.0117	0.0126	11.352	0.0049	0.0054
9-Octadecennnike12.8210.01290.13912.9340.01310.0121Vicine13.4190.02840.027813.4170.01640.017Dikydro-oxo-denethoxyhaennathamine14.1510.05240.037414.1610.01640.0202Augustamine14.0190.22080.237115.3440.01490.0137Oxoasoanhe15.3950.02940.031715.3940.0190.0131Cinchonine16.4770.02290.031416.4600.1620Cinchonine16.67248.80252.61116.6719.64016.326Protopine17.030.096310.38117.3970.0120.0321Alpha allecryptopine17.360.0620.03317.3970.0120.034Condinine18.540.0540.05415.440.01840.0291Tetrahydroculundamine18.540.0240.05415.450.03610.0321Copdisine18.540.0280.05415.4516.49918.650.0361Parkatine18.9716.47817.45518.7618.4990.03210.0361Copdisine18.9916.167817.45518.760.0220.024Parkatine19.9970.0530.05719.550.0220.024Copdisine19.9970.0580.05719.550.0520.058Parkatine19.9970.0580.05719.550.0520.058Copdisine <th>Zeatin</th> <th>12.096</th> <th>0.0331</th> <th>0.0356</th> <th>12.094</th> <th>0.0149</th> <th>0.0164</th>	Zeatin	12.096	0.0331	0.0356	12.094	0.0149	0.0164
Vicine13.4190.02580.027813.4170.01040.0117Dilydr-sco-demethscyhaenanthamine14.1510.05420.058414.1500.01840.0127Augustamine14.9190.22080.237914.1600.01310.0131Concosoaline16.2450.03810.041116.2440.01540.0132Cinchonine16.4520.33140.041116.2460.020841.0319Bughaniciron16.4529.31770.098916.4669.064021.6326Protopine17.0930.09631.03817.0890.04320.0432Alghanadiron17.620.0420.043317.3570.01620.0343Indicine-Novide18.040.07480.080618.0480.0294Coptishe18.3540.1080.130218.3490.04640.0546Paredine18.540.1080.130218.3490.04640.0546Interlaydrocolumbanine18.940.017518.3490.03120.031417.449Coptishe19.4000.0570.81518.767.4107.459Palmatine19.4000.0770.81519.370.0210.021Coptishe19.4000.0570.06119.4300.0230.021Coptishe19.4000.0570.05119.330.0230.021Coptishe19.4000.0570.05119.430.0230.021Coptishe19.4000.056 </th <th>9-Octadecenamide</th> <th>12.821</th> <th>0.0129</th> <th>0.0139</th> <th>12.936</th> <th>0.0113</th> <th>0.0124</th>	9-Octadecenamide	12.821	0.0129	0.0139	12.936	0.0113	0.0124
Dilydro-oxo-denethoxyhaenanthamine14.1510.05240.058414.1500.0187Augustamine14.9190.2080.237914.9160.16700.1837Oxoassonine15.3950.02340.031715.3460.0190.0131Cinchonine16.4520.3717100.988916.46637.298041.0319Biphanof16.4529.37177100.988916.46637.298041.0319Portopine16.6720.46252.651116.6720.0120.012Alpa allecryptopine17.3620.0420.43317.3570.01620.012Cindicine-N-oxide17.5480.05420.834417.5440.01840.0209Cindicine-N-oxide18.0540.07480.806018.4580.02160.0546Cindicine-N-oxide18.9540.07480.808018.95816.940918.658Cindiatine18.0540.07470.81518.95816.940918.658Cindiatine18.9590.0220.0240.02510.0220.024Cindiatine19.4000.0770.81518.9590.0220.024Cindiatine19.4000.8770.81518.950.0220.024Cindiatine19.4010.4970.81619.350.0220.024Cindiatine19.4020.8280.63652.4270.02310.254Cindiatine19.4590.8280.63652.1230.02310.0254Cindi	Vicine	13.419	0.0258	0.0278	13.417	0.0106	0.0117
Alegastamine14.9190.22080.237914.9160.16700.1837Oxassonine15.3950.02940.031715.3940.0110.0131Cinchonidine16.4250.03810.041116.3660.01200.0132Cinchoniz16.4529.37177100.988916.4660.1200.132Buphandrine16.67248.80252.651116.6679.06000.0132Alpha allexyptopine17.0930.09630.103817.3570.01620.0173Indicine-N-oxide17.5480.05420.054117.5440.01840.0291Tetrahydroclumbamine18.0540.07480.306018.0480.03120.0341Copisin18.0540.07870.18516.490918.6480.0320.0341Copisine19.4000.07770.081519.3930.03280.0361Berberine19.6900.02810.059119.0230.02310.0241Copisine1.1020.04770.48122.1230.02310.0241Copisine19.4000.05770.481519.3930.0220.0241Copisine19.6808.01490.05922.16370.02310.0241Copisine19.4920.04770.48122.1230.02310.0241Copisine19.4920.02410.05850.0220.02410.0241Copisine19.4920.03140.23560.02310.02410.0251Co	Dihydro-oxo-demethoxyhaemanthamine	14.151	0.0542	0.0584	14.150	0.0184	0.0202
Noxassonnine15.3950.02940.031715.3940.01190.0131Cinchonidine16.2450.03810.041116.2440.01540.0162Cinchonine16.3770.03290.035416.3660.01200.0132Cinane-Salpha-0116.67248.8022.2651116.66719.64021.632Baphanidrine16.07248.8020.038117.0870.01620.0178Alpha allocrybopine17.3620.0020.43317.3570.01620.0178Indiche-N-axide17.5480.05420.056418.480.0290.0381Coptisine18.540.1280.130218.3480.0290.0314Pawelline18.5516.4781.35118.340.0490.054Palmadine18.6516.4781.745518.49018.648Chronybphanidrine18.69981.14094.950419.6754.0021Ambelline19.6970.0530.05719.550.0220.024Gendyrobphanidrine2.4690.05280.0592.1420.0230.024Gronycine2.1220.04610.0530.1230.0240.0530.1630.021Gronycine2.1240.1130.1272.1810.0310.0210.0210.021Gronycine2.1940.0530.0362.1320.0360.0340.1320.0310.014Gronycine2.1940.0160.1130.1630.0	Augustamine	14.919	0.2208	0.2379	14.916	0.1670	0.1837
Cinchonidine16.2450.03810.41116.2440.01540.01200.0132Cinanc-3alpho-016.4570.3370.03541.63600.01200.0132Buphanidrine16.67248.80252.65111.66679.66400.0163Fortopine17.620.04020.43317.3570.01620.0173Alpha alleryptopine17.3620.04020.43317.3570.01620.0343Cintarine-Noxide17.5480.05420.080618.0480.03120.0343Coptisine18.8540.07480.806018.0480.04960.0496Powelline18.8521.6467817.45518.3541.04090.854Coptisine18.8521.647817.45518.767.41007.455Palmatine19.6750.081519.9350.03240.02140.024Childine-Noxiphphanidrine19.9570.00330.05719.9550.00240.024Childine-Noxiphphanidrine19.9570.00350.063021.320.0240.024Childine-Noxiphphanidrine21.320.04470.481221.320.0240.024Childine-Noxiphphanidrine21.920.0470.03121.320.0240.024Childine-Noxiphphanidrine21.920.0310.03121.320.0310.014Childine-Noxiphphanidrine21.920.0310.03121.920.0360.0140.032Childine-Noxiphphanidrine21.	Oxoassoanine	15.395	0.0294	0.0317	15.394	0.0119	0.0131
Cinchonine16.3770.03290.035416.3660.01200.0123Crinane-Japha-ol16.45293.7177100.988916.46637.298041.0319Buphanidrine16.07248.80252.651116.66719.664021.632Protopine17.0320.00200.033317.3570.01620.0403Alpha allocryptopine17.5480.0240.058417.5440.0180.024Terahydrochumhamine18.0540.07480.806618.0480.03120.0341Copisin18.5240.02345.315018.3540.04960.854Powelline18.52442.05245.315018.76516.9407.459Palmatine19.4000.07570.81519.3930.0210.0214Chydroxybuphanidrine19.69088.114094.954419.67543.840448.182Chydroxybuphanidrine21.020.0540.05719.9550.0220.024Chydroxybuphanidrine21.020.0540.05321.420.0240.024Chydroxybuphanidrine21.820.0580.063021.320.0510.051Chydroxybuphanidrine21.820.03520.03522.9460.0310.0151Chydroxybuphanidrine21.820.03650.03612.3260.0360.0352.9410.031Chydroxybuphanidrine21.820.0370.03632.9420.0310.01610.01610.01510.0161	Cinchonidine	16.245	0.0381	0.0411	16.244	0.0154	0.0169
Crinane-Salpha-ol16.45293.717100.988916.48637.298041.031Buphanidrine16.67248.80252.651116.66719.664021.632Protopine17.0930.09630.103817.0890.03680.0053Alphanidleryptopine17.3620.04020.038117.3570.01620.0178Indrine-Noxide17.5480.04920.058417.5440.01880.03120.0312Coptisine18.3540.12080.130218.3490.049618.4540.049618.4540.049618.4540.049618.4540.049618.4540.049618.4540.04960.05419.0400.05419.05119.0510.03280.03280.03280.03280.03140.127418.76518.76518.76518.76518.76518.76518.76518.76518.76518.76518.76518.76518.76518.76510.0510.05280.05210.05280.02210.02210.02140.	Cinchonine	16.377	0.0329	0.0354	16.366	0.0120	0.0132
Buphanitrine16.67248.80252.651116.6719.64021.6326Protopine17.0930.09630.103817.0890.03680.405Alpha allocryptopine17.3620.04020.043317.3570.01620.0178Indice-Noxide17.5480.05420.054317.5440.01820.0343Coptisine18.0540.07480.080618.0480.03120.0343Coptisine18.3540.12080.130218.3490.04960.0546Powelline18.59242.052345.315018.58516.49080.8061Undulatine19.4000.07570.81519.3930.03280.0321Ambelline19.9970.05280.056920.4670.02210.0241Berberine21.1020.04470.048221.1230.02310.0254Grogophine21.820.03120.05380.063021.3220.0530.055Firdarydrocoptisne21.820.01540.041721.8610.01530.01530.0153Gridamidine23.9670.2830.3052.3560.01530.01610.15100.1611Crinamidine23.9670.2830.316723.9630.15100.16110.017424.990.00370.00370.00370.00370.00370.01410.017424.990.00370.01610.15100.01610.01760.00370.01610.01760.00610.01760.0061	Crinane-3alpha-ol	16.452	93.7177	100.9889	16.486	37.2980	41.0319
Protopine17.0930.09630.103817.0890.03680.0403Alpha allocryptopine17.3620.04020.043317.3570.01620.0178Indicine-Noxide17.5480.05420.058417.5440.01880.0209Tetrahydrocolumbamine18.0540.07480.80018.0480.03120.0343Coptisine18.55242.052345.315018.58516.940018.6458Didultine18.76516.467817.745518.767.04107.7455Palmatine19.4000.07570.081519.3930.03280.0361Ambelline19.68988.114094.950419.67543.804048.1892Berberine19.0970.00530.005719.9550.00210.0254Goryonine21.1020.0170.016921.3220.02640.0254Goryonine21.3280.05820.603021.3220.02640.0254Goryonine21.3280.05840.031421.3230.02340.0584Goryonine21.3290.03160.031421.3230.03140.0584Griandine22.9960.02830.30152.9910.1300.1616Criandine26.94998.0202160.03652.682448.983058.3146Gurandine26.94998.0202106102.682448.930058.3146Gurandine26.94998.0202106102.682448.930058.3146<	Buphanidrine	16.672	48.8602	52.6511	16.667	19.6640	21.6326
Alpha allocryptopine17.3620.04020.043317.3570.01620.0178Indicine-Noxide17.5480.05420.058417.5440.01880.0209Tetrahydrocolumbamine18.0540.07480.806618.0480.03120.0343Coptisine18.3540.12080.130218.3490.04960.5546Powelline18.59242.052345.315018.58516.949018.6458Undulatine18.76516.467817.745518.767.0107.7459Palmatine19.60988.11409.4950419.6350.00220.0361Ambelline19.69888.11409.4950419.6750.00230.00210.0214Gerberine19.9570.00530.005719.5550.00220.0264Gerbyrine21.1020.04470.048221.1230.02310.0254Gerbyrine21.3280.05850.630221.3220.02690.2964Grinamidine22.3960.03160.31122.3560.11300.161Tetrahydrocoptishe22.3960.0210.06126.3230.31070.30310.312Kitan26.4670.28380.31723.9630.11300.1661Crinamidine26.49498.40201060.368526.82448.938053.83916Nitraphylin27.450.3820.3160.31227.950.00630.31728.930.31630.31630.31630.31630.3	Protopine	17.093	0.0963	0.1038	17.089	0.0368	0.0405
Indicine-N-oxide17.5480.05420.058417.5440.01880.0209Tetrahydrocolumbanine18.0540.07480.080618.0480.03120.0343Coptisine18.3540.12080.130218.3490.04960.0546Powelline18.59242.052345.315018.58516.949018.6458Undulatine18.76016.467817.745518.767.04107.7459Palmatine19.0600.07570.081519.9330.03280.0361Ambelline19.9570.00530.005719.9550.00220.02140.02146-Hydroxybuphanidrine20.4690.05280.059720.4670.02310.02546-Hydroxypowelline21.3220.04470.482221.1230.02540.02646-Hydroxypowelline21.8210.11390.122721.8160.05320.0585Nitdine2.3560.03610.03612.3260.01310.0143Crinamidine2.94910.02140.04112.3560.01310.0141Crinamidine2.6494984020106.368526.82448.9380538.916Mitraphylin2.7450.03120.0210.00310.01780.00630.0078Chitamidine2.649498.0220106.368526.82448.9380538.916Mitraphylin2.74550.03240.00160.017427.6550.00630.0017Chitamine2.86310.016 <t< th=""><th>Alpha allocryptopine</th><th>17.362</th><th>0.0402</th><th>0.0433</th><th>17.357</th><th>0.0162</th><th>0.0178</th></t<>	Alpha allocryptopine	17.362	0.0402	0.0433	17.357	0.0162	0.0178
Tetrahydrocolumbamine18.0540.07480.080618.0480.03120.0343Coptisine18.3540.12080.130218.3490.04960.0546Powelline18.59242.052345.315018.58516.949018.6458Undulatine18.76516.467817.745518.767.04107.7459Palmatine19.4000.07570.081519.3930.03280.0361Ambelline19.98988.114094.950419.67543.804048.1892Gerberine19.9570.00530.005719.9550.00220.0024Gerborine21.020.04470.048221.1230.02310.02610.0252Gerborine21.3280.0150.031421.3220.02690.02690.0552Gerborine21.8210.11390.122721.8160.05520.05520.0553Gerborine23.9670.02830.301723.9630.15100.161Grinamidine23.9670.28330.317223.9630.15100.161Grinamidine26.499984.02201060.368526.824489.398053.8316Vacangine27.060.021728.6290.00370.00230.00170.01830.01780.01780.0198Grinamidine26.949984.02201060.368526.824489.398053.83160.01960.01780.00570.005129.5510.00630.00510.00520.00510.01	Indicine-N-oxide	17.548	0.0542	0.0584	17.544	0.0188	0.0209
Copusine18.3540.12080.130218.3490.04960.0546Powelline18.59242.052345.315018.58516.949018.6458Undulatine18.76516.467817.745518.767.04107.7459Palmatine19.4000.07570.081519.3930.03280.0361Ambelline19.68988.114094.950419.67543.804048.1892Berberine19.9570.00530.005719.9550.00220.00246 Hydroxybuphanidrine20.4690.05280.066021.4220.02310.0254Arongvine21.1020.04470.048221.1230.02310.05546 Hydroxybuphanidrine21.8210.11390.122721.8160.05320.05856 Hydroxybuphanidrine21.9320.02540.05320.01530.0168Fitrahydrocoptisine21.9960.02830.031423.560.01530.0168Fitrahydrocoptisine20.694984.02201060.368526.824489.398058.3916Voacangine27.060.021427.0580.01780.01940.0196Mitraphylin27.4550.03520.035428.9170.00820.0097Chitamine28.9150.016428.9170.00820.00970.018428.9170.00820.0097Fitrancine28.9150.00360.035429.5110.00420.00430.00430.00430.0043Chitami	Tetrahydrocolumbamine	18.054	0.0748	0.0806	18.048	0.0312	0.0343
Powelline18.59242.052345.315018.58516.949018.6458Undulatine18.76516.467817.745518.767.04107.7459Palmatine19.4000.07570.081519.3930.03280.0361Ambelline19.68988.114094.950419.67543.804048.1892Berberine19.9570.00530.005719.9550.00220.02416 Hydroxybuphanidrine20.4690.5280.56921.4230.02310.0254Monocrotaline21.1020.04470.048221.1230.02690.02966 Hydroxypowelline21.8210.11390.122721.8160.05320.0585Nitidine22.3590.03160.304122.3560.01330.0143Crinamidine23.9670.28830.30723.9630.15100.1661Echitamidine26.6280.00570.06126.7320.00370.0041Akammidine26.949984.0201060.368526.824489.3980538.3916Voacangine27.060.02010.021727.0580.01780.0196Mitraphylin27.4250.03620.001728.6290.00920.001Colchcine28.9150.01960.011920.5710.00240.0017Envine25.550.03640.051429.7180.00240.0271Fitmanice25.550.01960.011829.7180.00240.0014C	Coptisine	18.354	0.1208	0.1302	18.349	0.0496	0.0546
Idudatine18.76516.467817.745518.767.04107.7459Palmatine19.4000.07570.081519.3930.03280.0361Ambelline19.68988.114094.950419.67543.804048.1892Berberine19.9570.00530.005719.9550.00220.02416.Hydroxybuphanidrine20.4690.05280.05692.0.4670.02310.0254Monocrotaline21.1020.04470.048221.1230.02640.02966.Hydroxypowelline21.3280.05850.630021.3220.02640.0585Nitidine22.3590.03160.034122.3560.01530.0168Tetrahydrocoptisine23.9670.28830.310723.9630.01510.041Kammidine26.8280.00570.006126.324489.3980538.3916Voacangine27.060.20110.021727.6350.0070.001Mitraphylin27.4250.03820.011127.6350.00630.007Clochcine28.0150.01590.012728.6370.00240.0021Clochcine28.9150.01590.02829.9170.00240.0021Clochcine29.9150.016429.9150.00240.0021Mitraphine27.4250.03820.011127.6350.00630.0014Clochcine28.9150.01590.012828.9170.00240.0021Clochcine <th>Powelline</th> <th>18.592</th> <th>42.0523</th> <th>45.3150</th> <th>18.585</th> <th>16.9490</th> <th>18.6458</th>	Powelline	18.592	42.0523	45.3150	18.585	16.9490	18.6458
Palmatine19.4000.07570.081519.3930.03280.0361Ambelline19.68988.114094.950419.67543.804048.1822Berberine19.9570.00530.05719.9550.00220.00246-Hydroxybuphanidrine20.4690.5280.5692.1420.02310.254Acronycine21.1020.04470.04822.1230.02940.02946-Hydroxybuphanidrine21.3280.05850.6302.13220.02940.02966-Hydroxypowelline21.8210.11390.12272.18160.05320.0585Nitidine22.3590.03160.03412.3560.01330.0168Fetrahydrocoptisine23.9670.28330.31072.39630.15100.161Fetrianidine26.8280.0570.00612.6320.00370.0041Fetrianidine26.949984.0201060.36852.6824489.3980538.3916Mitraphylin27.4250.0320.01712.70580.01780.0196Fetrianine28.6310.0160.01712.6290.00910.0101Fetrianine28.9150.03640.03912.9710.0240.0271Fetrianine29.550.0360.0392.9710.0240.0271Fetrianine29.7550.0360.0392.9710.0240.0413Fetrianine29.7550.0360.0352.9740.0390.043Fet	Undulatine	18.765	16.4678	17.7455	18.76	7.0410	7.7459
Ambelline19.68988.114094.950419.67543.804048.1892Berberine19.9570.00530.005719.9550.00220.02476-Hydroxybuphanidrine20.4690.05280.056920.4670.02370.261Acronycine21.1020.04470.482221.1230.02690.02686-Hydroxypowelline21.3280.05850.063021.3220.02690.02686-Hydroxypowelline22.3590.03160.034122.3560.01530.01687-terahydrocoptisine22.9960.28330.30522.9910.01300.14316-Ehitamidine26.8280.00570.061126.3230.03160.031423.9630.01716-Exitamidine26.499984.02201060.368526.824489.3980538.39167-taminine27.050.021727.0580.01780.01920.01926-Exitamidine28.6310.0160.017128.6290.00910.01926-Exitamine28.5550.03660.039129.5710.00240.02716-Enterine29.5550.03660.039429.5710.00240.02716-Enterine29.7430.05090.055429.7480.0390.04347-tandrine29.5550.03660.039429.5710.00240.02746-Enterine29.7430.05590.055429.7480.03940.04348-tandrine29.5710.02440.0434 <th>Palmatine</th> <th>19.400</th> <th>0.0757</th> <th>0.0815</th> <th>19.393</th> <th>0.0328</th> <th>0.0361</th>	Palmatine	19.400	0.0757	0.0815	19.393	0.0328	0.0361
Berberine19.9570.00530.005719.9550.00240.00246-Hydroxybuphanidrine20.4690.05280.056920.4670.02370.0261Acronycine21.1020.04470.048221.1230.02310.0254Monocrotaline21.3280.05850.663021.3220.02690.02966-Hydroxypowelline21.8210.11390.122721.8160.05320.0585Nitidine22.3590.03160.034122.3560.01530.0168Tetrahydrocoptisine23.9670.28830.310723.9630.15100.1661Echtamidine26.3280.0570.006126.7320.00370.0041Joacangine27.060.20110.021727.0580.01780.0196Mitraphylin27.4250.03820.011127.6350.00630.0070Echtiamine28.9150.01680.017328.6290.00900.0101Fenetine29.7430.00500.003129.7510.00240.0024Gladikaloids content29.7430.00500.005429.7480.0390.043	Ambelline	19.689	88.1140	94.9504	19.675	43.8040	48.1892
6-Hydroxybuphanidrine20.4690.05280.056920.4670.02370.0261Acronycine21.1020.04470.048221.1230.02310.0254Monocrotaline21.3280.05850.063021.3220.02690.02966-Hydroxypowelline21.8210.11390.122721.8160.05320.0585Nitdine22.3590.03160.034122.3560.01530.0168Tetrahydrocoptisine22.9960.28830.305723.9630.15100.1611Crinamidine23.9670.28830.310723.9630.15100.0413Kuammidine26.8280.00570.006126.7320.00370.0041Kuammidine27.060.20210.017127.0580.01780.0196Mitraphylin27.4250.03820.017128.6290.00900.0010Colchcine28.9150.01360.012828.9170.00820.0091Fuerine29.5550.00360.003929.5710.00240.0024Total alkaloids content29.7431292.46001392.729552.4420684.754	Berberine	19.957	0.0053	0.0057	19.955	0.0022	0.0024
Acronycine21.1020.04470.048221.1230.02310.0254Monocrotaline21.3280.05850.063021.3220.02690.02966-Hydroxypowelline21.8210.11390.122721.8160.05320.0585Nitidine22.3590.03160.034122.3560.01530.0168Crinamidine23.9670.28830.310723.9630.15100.1661Echitamidine26.8280.00570.006126.7320.00370.0041Akuanmidine26.949984.0201060.368526.824489.3980538.3916Voacangine27.4250.03820.011127.6350.00630.0070Mitraphylin28.6310.01640.012828.9170.00820.0091Colchcine29.5550.00360.003929.5710.00240.0027Farendrine29.7430.0501392.729552.4420684.7548	6-Hydroxybuphanidrine	20.469	0.0528	0.0569	20.467	0.0237	0.0261
Monocrotaline21.3280.05850.063021.3220.02690.02966-Hydroxypowelline21.8210.11390.122721.8160.05320.0585Nitidine22.3590.03160.034122.3560.01530.0168Tetrahydrocoptisine22.9960.02830.305522.9910.01300.1431Crinamidine23.9670.28830.310723.9630.15100.1661Echitamidine26.8280.00570.006126.7320.00370.0041Akuammidine26.949984.02201060.368526.824489.3980538.3916Voacangine27.060.02110.021727.0580.01780.0170Bitraphylin27.4250.03820.041127.6350.00630.0070Colchcine28.9150.01190.12828.9170.00820.0090Emetine29.5550.00360.003929.5710.00240.0027Tetrandrine29.7430.00500.005429.7480.00390.043	Acronycine	21.102	0.0447	0.0482	21.123	0.0231	0.0254
6-Hydroxypowelline21.8210.11390.122721.8160.05320.0585Nitidine22.3590.03160.034122.3560.01530.0168Tetrahydrocoptisine22.9960.02830.30522.9910.13000.1431Crinamidine23.9670.28830.310723.9630.15100.1661Echitamidine26.8280.00570.006126.7320.00370.0041Akuammidine26.949984.02201060.368526.824489.3980538.3916Voacangine27.4250.03820.011127.6350.00630.0070Bittiamine28.6310.0160.01728.6290.00900.0101Colchicine28.9150.01360.012828.9170.00820.0097Emetine29.5550.00360.003929.5710.00240.0027Tetrandrine29.7430.00501292.46001392.729552.4420684.7548	Monocrotaline	21.328	0.0585	0.0630	21.322	0.0269	0.0296
Nitidine22.3590.03160.034122.3560.01530.0168Tetrahydrocoptisine22.9960.02830.030522.9910.01300.0143Crinamidine23.9670.28830.310723.9630.15100.1661Echitamidine26.8280.00570.006126.7320.00370.0041Akuammidine26.949984.02201060.368526.824489.3980538.3916Voacangine27.060.02010.021727.0580.01780.0196Mitraphylin27.4250.03820.041127.6350.00630.0070Echitamine28.6310.01190.012828.9170.00820.0090Colchicine29.5550.00360.003929.5710.00240.0027Tetrandrine29.7430.00501392.729552.4420684.7548	6-Hydroxypowelline	21.821	0.1139	0.1227	21.816	0.0532	0.0585
Tetrahydrocoptisine22.9960.02830.030522.9910.01300.0143Crinamidine23.9670.28830.310723.9630.15100.1661Echitamidine26.8280.00570.006126.7320.00370.0041Akuammidine26.949984.02201060.368526.824489.3980538.3916Voacangine27.060.02010.021727.0580.01780.0196Mitraphylin27.4250.03820.041127.6350.00630.0070Echitamine28.6310.00160.001728.6290.00900.0010Colchicine29.5550.00360.003929.5710.00240.0027Tetrandrine29.7430.00501392.729552.4420684.7548	Nitidine	22.359	0.0316	0.0341	22.356	0.0153	0.0168
Crinamidine23.9670.28830.310723.9630.15100.1661Echitamidine26.8280.00570.006126.7320.00370.0041Akuammidine26.949984.02201060.368526.824489.3980538.3916Voacangine27.060.02010.021727.0580.01780.0196Mitraphylin27.4250.03820.041127.6350.00630.0070Echitamine28.6310.00160.001728.6290.00900.0101Colchicine28.9150.01360.003929.5710.00820.0027Emetine29.7430.00500.005429.7480.00390.02440.0043	Tetrahydrocoptisine	22.996	0.0283	0.0305	22.991	0.0130	0.0143
Echitamidine       26.828       0.0057       0.0061       26.732       0.0037       0.0041         Akuammidine       26.949       984.0220       1060.3685       26.824       489.3980       538.3916         Voacangine       27.06       0.0211       0.0217       27.058       0.0178       0.0196         Mitraphylin       27.425       0.0382       0.0411       27.635       0.0063       0.0070         Echitamine       28.631       0.0016       0.0017       28.629       0.00090       0.0101         Colchicine       28.915       0.0119       0.128       28.917       0.0082       0.0090         Emetine       29.555       0.0036       0.0039       29.571       0.0024       0.0027         Tetrandrine       29.743       0.0050       1392.7295       52.4420       684.7548	Crinamidine	23.967	0.2883	0.3107	23.963	0.1510	0.1661
Akuammidine       26.949       984.0220       1060.3685       26.824       489.3980       538.3916         Voacangine       27.06       0.0201       0.0217       27.058       0.0178       0.0196         Mitraphylin       27.425       0.0382       0.0411       27.635       0.0063       0.0070         Echitamine       28.631       0.0016       0.0017       28.629       0.0090       0.0100         Colchicine       28.915       0.0136       0.0128       28.917       0.0082       0.0090         Emetine       29.555       0.0036       0.0039       29.571       0.0024       0.0027         Tetrandrine       29.743       0.0050       1392.7295       52.4420       684.7548	Echitamidine	26.828	0.0057	0.0061	26.732	0.0037	0.0041
Voacangine       27.06       0.0201       0.0217       27.058       0.0178       0.0196         Mitraphylin       27.425       0.0382       0.0411       27.635       0.0063       0.0070         Echitamine       28.631       0.0016       0.0017       28.629       0.0090       0.0010         Colchicine       28.915       0.0136       0.0039       29.571       0.0024       0.0027         Emetine       29.743       0.0050       0.0054       29.748       0.0039       0.0039       0.0039         Total alkaloids content       1292.4600       1392.7295       622.4420       684.7548	Akuammidine	26.949	984.0220	1060.3685	26.824	489.3980	538.3916
Mitraphylin         27.425         0.0382         0.0411         27.635         0.0063         0.0070           Echitamine         28.631         0.0016         0.0017         28.629         0.0009         0.0010           Colchicine         28.915         0.0119         0.0128         28.917         0.0082         0.0090           Emetine         29.555         0.0036         0.0039         29.571         0.0024         0.0027           Tetrandrine         29.743         0.0050         0.0054         29.748         0.0039         0.0039         622.4420         684.7548	Voacangine	27.06	0.0201	0.0217	27.058	0.0178	0.0196
Echitamine       28.631       0.0016       0.0017       28.629       0.0009       0.0010         Colchicine       28.915       0.0119       0.0128       28.917       0.0082       0.0090         Emetine       29.555       0.0036       0.0039       29.571       0.0024       0.0027         Tetrandrine       29.743       0.0050       0.0054       29.748       0.0039       0.0039       62.4420       684.7548	Mitraphylin	27.425	0.0382	0.0411	27.635	0.0063	0.0070
Colchicine         28.915         0.0119         0.0128         28.917         0.0082         0.0090           Emetine         29.555         0.0036         0.0039         29.571         0.0024         0.0027           Tetrandrine         29.743         0.0050         0.0054         29.748         0.0039         0.0039         0.0039           Total alkaloids content         1292.4600         1392.7295         622.4420         684.7548	Echitamine	28.631	0.0016	0.0017	28.629	0.0009	0.0010
Emetine         29.555         0.0036         0.0039         29.571         0.0024         0.0027           Tetrandrine         29.743         0.0050         0.0054         29.748         0.0039         0.0043           Total alkaloids content         1292.4600         1392.7295         622.4420         684.7548	Colchicine	28.915	0.0119	0.0128	28.917	0.0082	0.0090
Tetrandrine         29.743         0.0050         0.0054         29.748         0.0039         0.0043           Total alkaloids content         1292.4600         1392.7295         622.4420         684.7548	Emetine	29.555	0.0036	0.0039	29.571	0.0024	0.0027
<b>Total alkaloids content</b> 1292.4600 1392.7295 622.4420 684.7548	Tetrandrine	29.743	0.0050	0.0054	29.748	0.0039	0.0043
	Total alkaloids content		1292.4600	1392.7295		622.4420	684.7548

Compound		Leaves		Stems		
	Retention time	Composit	ion (mg/kg)	Retention time Comp		(mg/kg)
	(min)	Fresh	dry	(min)	Fresh	Dry
Phytosterols						
Cholesterol	19.600	0.00289	0.00311	19.395	0.00098	0.00108
Cholestanol	20.605	0.00011	0.00012	20.460	0.00005	0.00006
Ergosterol	21.509	0.01836	0.01978	21.394	0.01829	0.02012
Campesterol	22.375	10.86360	11.70647	22.311	4.55842	5.01476
Stigmasterol	23.208	12.18540	13.13082	23.062	7.83465	8.61898
5-Avenasterol	24.005	9.50895	10.24671	23.852	8.18951	9.00936
Sitosterol	25.031	57.01620	61.43987	25.261	51.12140	56.23916
Total phytosterol content		89.59560	96.54688		71.72330	78.90352
Terpenoids						
Taraxerol	19.399	0.01286	0.01386	19.401	0.01402	0.01542
Alpha-amyrin	21.131	2.21037	2.38186	21.102	1.27591	1.40364
Beta-amyrin	21.820	3.65475	3.93831	21.822	4.58234	5.04108
Lupeol	23.229	1.11087	1.19706	23.234	1.02418	1.12671
Bauerenol acetate	24.728	0.01502	0.01619	24.792	0.01304	0.01434
Total terpenoids content		7.00388	7.54728		6.90949	7.60120
Allicins						
Diallyl thiosulphinate	16.448	0.00135	0.00145	16.455	0.01573	0.01731
Methylallyl thiosulphinate	17.699	0.07302	0.07868	17.698	0.11177	0.12295
Allylmethyl thiosulphinate	18.773	0.00670	0.00722	18.744	0.00136	0.00150
Total allicins content		0.09319	0.08736		0.12886	0.14176

Table 8. Composition of phytosterols, terpenoids and allicins isolated and detected in the leaves and stems of Cnidoscolus aconitifolius

Forty four known alkaloids were detected in the leaves and stems (Table 7), consisting mainly of akuammidine (leaves: 76.14%; stems: 78.63%), crinane-3alpha-ol (leaves: 7.25%; stems: 5.99%), ambelline (leaves: 6.82%; stems: 7.04%), buphanidrine (leaves: 3.78%; stems: 3.16%), powelline (leaves: 3.25%; stems: 2.72%), undulatine (leaves: 1.27%; stems: 1.13%), lupanine (leaves: 1.06%; stems: 0.91%) and serotonin (leaves: 0.22%; stems: 0.20%). The leaves and stems had lower akuammidine and ambelline, and higher powelline, crinane-3a-ol and buphanidrine than T. procumbens [19]. Akuammidine has analgesic, antibacterial, anti-depressant, antifungal, anti-inflammatory, antimalarial, hypotensive and skeletal muscle relaxant activities [19, 64]. Buphanidrine is an antibacterial and sedative [65]. Lupanine is an anti-arrhythmic, bacteriostatic, hypotensive, hypoglycaemic, β-glucosidase inhibitory, central nervous system depressant and oxytocic agent [19].

Three known allicins were detected in the leaves and stems (Table 8), consisting of methylallyl thiosulphinate (leaves: 90.07%; stems: 86.73%), allylmethyl thiosulphinate (leaves: 8.27%; stems: 1.06%) and diallyl thiosulphinate (leaves: 1.66%; stems: 12.21%). Five known terpenoids were detected in the leaves and stems (Table 8), consisting of beta-amyrin (leaves: 52.18%; stems: 66.32%), alpha-amyrin (leaves: 31.56%; stems: 18.47%), lupeol (leaves: 15.86%; stems: 14.82%), bauerenol acetate (leaves: 0.21%; stems: 0.19%) and taraxerol (leaves: 0.18%; stems: 0.20%). Amyrins ( $\alpha$  and  $\beta$ ) possesses analgesic, anti-colitis, anticonvulsant, anti-depressive, antifungal, anti-hyperglycaemic, anti- inflammatory, antimicrobial, anti-obesity, antioxidant, antipancreatitis, antipruritic, antiplatelet, gastroprotective, hepatoprotective and hypolipidaemic properties [66-68]. Lupeol anti-diabetic, anti-inflammatory, exhibits anti-arthritic, antimicrobial, antiprotozoal, antitumor, cardio-protective and hepatoprotective properties [41, 59, 69, 70].

From the foregoing, it can be concluded that the leaves and stems of *C. aconitifolius* are good sources of macro- and micronutrients, which could be exploited in supplementing the nutrient contents of the human diet. It can also be concluded that the leaves and stems contain a wide range of bioactive phytochemicals. The useful roles of these phytoconstituents can be exploited in the human diet, making them real tools for nutritional therapy. This, therefore, underscores the potential of these leaves and stems as functional foods.

#### CONFLICT OF INTEREST

The authors declare that there is no conflict of interests regarding the publication of this manuscript.

#### REFERENCES

1. Omotoso, A.E., Eseyin, O.O. and Suleiman, M. (2014) Phytochemical analysis of *Cnidoscolus aconitifolius* (Euphorbiaceae) leaf with spectrometric techniques. *Nigerian J. Pharmaceut. Applied Sci. Res.* **3**(1), 38-49.

2. Achi, N.K. and Ohaeri, O.C. (2015) GC-MS determination of bioactive constituents of the methanolic fractions of *Cnidoscolus aconitifolius*. *Brit. J. Pharmaceut. Res.* **5**(3), 163-172.

3. Donkoh, A., Atuahene, C.C., Poku-Prempeh, Y.B. and Twum, I.G. (1999) The nutritive value of chaya leaf meal (*Cnidoscolus aconitifolius* (Mill.) Johnston): studies with broiler chickens. *Anim. Feed Sci. Technol.* **77**(1-2), 163-172.

4. Orji, O.U., Ibiam, U.A., Aja, P.M., Ugwu Okechukwu, P.C., Uraku, A.J., Aloke, C., Obasi, O.D. and Nwali, B.U. (2016) Evaluation of the phytochemical and nutritional profiles of *Cnidoscolus aconitifolius* leaf collected in Abakaliki South East Nigeria. *World J. Med. Sci.* **13**(3), 213-217.

5. Otitolaiye, C.A. and Asokan, C. (2016) GC-MS Analysis of *Cnidoscolus aconitifolius* leaf aqueous extracts. *Intern. J. Sci. Res.* **5**(8), 471-475.

6. Azeez, O.I., Oyagbemi, A.A., Oyeyemi, M.O. and Odetola, A.A. (2010) Ameliorative effects of *Cnidoscolus aconitifolius* on alloxan toxicity in Wistar rats. *Afr. Health Sci.* **10**(3), 283-291.

7. AOAC International (2006) In: W. Horwitiz, (ed). *Official Methods of Analysis of the AOAC*, 18th edn. Gaithersburg, MD, USA: AOAC International.

8. Ikewuchi, J.C., Ikewuchi, C.C. and Ifeanacho, M.O. (2019) Nutrient and bioactive compounds composition of the leaves and stems of *Pandiaka heudelotii*: A wild vegetable. *Heliyon* **5**(4), e01501.

9. Motsara, M.R. and Roy, R.N. (2008) *Guide to laboratory establishment for plant nutrient analysis.* FAO Fertilizer and Plant Nutrition Bulletin 19. Rome: Food and Agriculture Organization of the United Nations.

10. Food and Drug Administration (2013) Food labelling guide: Guidance for industry. USA: Department of Health and Human Services.

11. Obreshkova, D.P., Tsvetkova, D.D. and Ivanov, K.V. (2012) Simultaneous identification and determination of total content of amino acids in food supplements – tablets by gas chromatography. *Asian J. Pharmaceut. Clin. Res.* **5**(Suppl. 2), 57-68.

12. FAO (2013) *Dietary protein quality evaluation in human nutrition*. Report of an FAO Expert Consultation, 31 March–2 April, 2011,

Auckland, New Zealand. FAO Food and Nutrition Paper 92. Rome: Food and Agriculture Organization of the United Nations.

13. Ngounou, F.N., Manfouo, R.N., Tapondjou, L.A., Lontsi, D., Kuete, V., Penlap, V., Etoa, F.X., Dubois, M-A.L. and Sondengam, B.L. (2005) Antimicrobial diterpenoid alkaloids from *Erythrophleum suaveolens* (Guill. & Perr.) Brenan. *Bull. Chem. Soc. Ethiopia* **19**(2), 221-226.

14. Chehregani, A., Azimishad, F. and Alizade, H.H. (2007) Study on antibacterial effect of some allium species from Hamedan-Iran. *Intern. J. Agric. Biol.* **9**(6), 873-876.

15. Takagi, S. (1985) Determination of green leaf carotenoids by HPLC. *Agric. Biol. Chem.* **49**(4), 1211-1213.

16. Oluwaniyi, O.O. and Ibiyemi, S.A. (2007) A study of the extractability of thevetia glycosides with alcohol mixture. *J. Food Technol.* **5**(2), 147-151.

17. Guo, M., Zhang, L. and Liu, Z. (2009) Analysis of saponins from leaves of *Aralia elata* by liquid chromatography and multi-stage tandem mass spectrometry. *Anal. Sci.* **25**(6), 753-758.

18. Ifeanacho, M.O., Ikewuchi, C.C. and Ikewuchi, J.C. (2019) Anti-diabetic effect of a flavonoid and sitosterol - rich aqueous extract of *Pleurotus tuberregium* sclerotia in alloxan-induced diabetic rabbits. *End Metab. Imm. Dis. Drug Targ.* 19, 1 Doi: 10.2174/ 1871530319666190206213843

19. Ikewuchi, C.C., Ikewuchi, J.C. and Ifeanacho, M.O. (2015) Phytochemical composition of *Tridax procumbens* Linn leaves: Potential as a functional food. *Food Nutr. Sci.* **6**(11), 992-1004.

20. Farah, A. (2012) Coffee constituents. In: Chu Y.F. (ed). *Coffee: emerging health effects and disease prevention*, 1st edn. Oxford, UK: John Wiley and Sons, Inc.

21. U.S. Department of Agriculture (2016) USDA National Nutrient Database for Standard Reference, Release 28 slightly revised May, 2016, Software v.3.7.1 2017-03-29. The National Agricultural Library. Nutrient data for: 11109, Cabbage, raw. https://ndb.nal.usda.gov/ndb/foods/show/2888?format=Full&reportfmt=pd f&pdfQvs=%7Bn1%3D%7BQv%3D1%7D%2C+Qv%3D1%7D&ds= (accessed June 3, 2017)

22. U.S. Department of Agriculture (2016) USDA National Nutrient Database for Standard Reference, Release 28 slightly revised May, 2016, Software v.3.7.1 2017-03-29. The National Agricultural Library. Nutrient data for: 11253, Lettuce, green leaf, raw. https://ndb.nal.usda.gov/ndb/foods/show/3003?format=Full&reportfmt=pd f&pdfQvs=%7Bn1%3D%7BQv%3D1%7D%2C+Qv%3D1%7D&ds= (accessed June 3, 2017).

23. U.S. Department of Agriculture (2016) USDA National Nutrient Database for Standard Reference, Release 28 slightly revised May, 2016, Software v.3.7.1 2017-03-29. The National Agricultural Library. Nutrient data for: 11257, Lettuce, red leaf, raw. https://ndb.nal.usda.gov/ndb/foods/show/3006?format=Full&reportfmt=pd f&pdfQvs=%7Bn1%3D%7BQv%3D1%7D%2C+Qv%3D1%7D&ds= (accessed June 3, 2017).

24. U.S. Department of Agriculture (2016) USDA National Nutrient Database for Standard Reference, Release 28 slightly revised May, 2016, Software v.3.7.1 2017-03-29. The National Agricultural Library. Nutrient data for: 11003, Amaranth leaves, raw. https://ndb.nal.usda.gov/ndb/foods/show/2816?format=Full&reportfmt=pd f&pdfQvs=%7Bn1%3D%7BQv%3D1%7D%2C+Qv%3D1%7D&ds= (accessed June 3, 2017).

Ikewuchi, J.C., Ikewuchi, C.C. and Igboh, M.N. (2009)
 Chemical profile of *Tridax procumbens* Linn. *Pak. J. Nutr.* 8(5), 548-550.
 Jancurová, M., Minarovičová, L. and Dandár, A. (2009)
 Quinoa - A review. *Czech J. Food Sci.* 27(2), 71-79.

27. Vega-Galvez, A., Miranda, M., Vergara, J., Uribe, E., Puente, L. and Martınez, E.A. (2010) Nutrition facts and functional potential of quinoa (*Chenopodium quinoa* willd.), an ancient Andean grain: a review. *J. Sci. Food Agric.* **90**, 2541-2547.

28. Gntechwitz, D., Reichardt, N., Blaut, M., Steinhart, H. and Bunzel, M. (2007) Dietary fiber from coffee beverage: degradation by human fecal microbiota. *J. Agric. Food Chem.* **55**, 6989-6996.

29. Korkmaz, S., Ekici, F., Tufan, H.A. and Aydın, B. (2013) Magnesium: Effect on ocular health as a calcium channel antagonist. *J. Clin. Exp. Invest.* **4**(2), 244-251.

30. National Academy of Sciences (1993) *Diet and health: Implications for reducing chronic disease risk.* National Academy Press, Washington.

31. Culotta, V.C., Yang, M. and Hall, M.D. (2005) Manganese transport and trafficking: Lessons learned from Saccharomyces cerevisiae. *Eukaryotic Cell* **4**(7), 1159-1165.

32. Martinez-Finley, E.J., Chakraborty, S. and Aschner, M. (2013). Manganese in biological systems. In: Kretsinger R.H., Uversky V.N. and Permyakov E.A. (eds.). *Encyclopedia of Metalloproteins*. Springer, New York.

33. Hurley, L.S. and Keen, C.L. (1987) Manganese. In: Mertz W. (ed). *Trace elements in human and animal nutrition*, 5th edn. Academic Press, New York, pp. 185-223.

34. Lee, K.J., Kim, K.S., Kim, H.N., Seo, J.A. and Song, S.W. (2014) Association between dietary calcium and phosphorus intakes, dietary calcium/phosphorus ratio and bone mass in the Korean population. *Nutr. J.* **13**(1), 114.

35. Koshihara, M., Katsumata, S., Uehara, M. and Suzuki, K. (2005) Effects of dietary phosphorus intake on bone mineralization and calcium absorption in adult female rats. *Biosci. Biotech. Biochem.* **69**(5), 1025-1028.

36. Adatorwovor, R., Roggenkamp, K. and Anderson, J.J.B. (2015) Intakes of calcium and phosphorus and calculated calcium-to-phosphorus ratios of older adults: NHANES 2005–2006 Data. *Nutrients* **7**, 9633-9639.

37. Ikewuchi, J.C. and Ikewuchi, C.C. (2009) Comparative study of the mineral element composition of some common Nigerian medicinal plants. *Pac. J. Sci. Tech.* **10**, 362-366

38. Kilgour, O.F.G. (1987) *Mastering nutrition*. Macmillian Education Ltd., London

39. Ikewuchi, C.C. and Ikewuchi, J.C. (2009) Comparative study on the vitamin composition of some common Nigerian medicinal plants. *Pac. J. Sci. Tech.* **10**(1), 367-371

40. Venskutonis, P.R. and Kraujalis, P. (2013) Nutritional components of amaranth seeds and vegetables: A review on composition, properties, and uses. *Comp. Rev. Food Sci. Food Safety* **12**, 381-412.

41. Jan, N., Andrabi, K.I. and John R. (2017) *Calendula officinalis* - An important medicinal plant with potential biological properties. *Proc. Indian Nat. Sci. Acad.* **83**(4), 769-787.

42. Rutherfurd, S.M., Fanning, A.C., Miller, B.J. and Moughan, P.J. (2015) Protein digestibility corrected amino acid scores and digestible

indispensable amino acid scores differentially describe protein quality in growing male rats. J. Nutr. 145(2), 372-379.

43. Jaswir, I., Noviendri, D., Hasrini, R.F. and Octavianti, F. (2011) Carotenoids: Sources, medicinal properties and their application in food and nutraceutical industry. *J. Med Plants Res.* **5**(33), 7119-7131

44. Eldahshan, O.A. and Singab, A.N.B. (2013) Carotenoids. J. Pharmacog. Phytochem. 2(1), 225-234

45. Kotake-Nara, E. and Nagao, A. (2011) Absorption and metabolism of xanthophylls. *Marine Drugs* **9**, 1024-1037

46. Patel, B., Marar, T. and Bhat, M. (2016) Study of biological activities and characterization of the crude orange pigment isolated from a distinct *Salinicoccus sp.* MKJ997975. *IOSR J. Biotech. Biochem.* **2**(5), 58-61

47. Pasquet, V., Morisset, P., Ihammouine, S., Chepied, A., Aumailley, L., Berard, J.B., Serive, B., Kaas, R., Lanneluc, I., Thiery, V., Lafferriere, M., Piot, J.M., Patrice, T., Cadoret, J.P. and Picot, L. (2011) Antiproliferative activity of violaxanthin isolated from bioguided fractionation of *Dunaliella tertiolecta* extracts. *Marine Drugs* **9**, 819-831

48. Yuan, J.P., Peng, J., Yin, K. and Wang, J.H. (2011) Potential health-promoting effects of astaxanthin: A high-value carotenoid mostly from microalgae. *Mol. Nutr. Food Res.* **55**(1), 150-165

49. Shimode, S., Miyata, K., Araki, M. and Shindo, K. (2018) Antioxidant activities of the antheraxanthin-related carotenoids, antheraxanthin, 9-cis-antheraxanthin, and mutatoxanthins. *J. Oleo Sci.* **67**(8), 977-981

50. Weathers, P.J. and Towler, M.J. (2012) The flavonoids casticin and artemetin are poorly extracted and are unstable in an *Artemisia annua* tea infusion. *Planta Med.* **78**(10), 1024-1026

51. de Souza, P., Gasparotto Jr., A., Crestani, S., Stefanello, M.E.A., Marquesa, M.C.A., da Silva-Santos, J.E. and Kassuya, C.A.L. (2011) Hypotensive mechanism of the extracts and artemetin isolated from *Achillea millefolium* L. (Asteraceae) in rats. *Phytomedicine* **18**(10), 819-825

52. Ogwang, P.E., Ogwal, J.O., Kasasa, S., Olila, D., Ejobi, F., Kabasa, D. and Obua, C. (2012) *Artemisia annua* L. infusion consumed once a week reduces risk of multiple episodes of malaria: A randomised trial in a Ugandan Community. *Trop. J. Pharmaceut. Res.* **11**(3), 445-453

53. Grossini, E., Marotta, P., Farruggio, S., Sigaudo, L., Qoqaiche, F., Raina, G., de Giuli, V., Mary, D., Vacca, G. and Pollastro, F. (2015) Effects of artemetin on nitric oxide release and protection against peroxidative injuries in porcine coronary artery endothelial cells. *Phytother. Res.* **29**, 1339-1348.

54. Ifeanacho, M.O., Ikewuchi, C.C. and Ikewuchi, J.C. (2017) Investigation of the profile of phenolic compounds in the leaves and stems of *Pandiaka heudelotii* using gas chromatography coupled with flame ionization detector. *Food Sci. Nutr.* **5**, 646-665

55. Elbaz, H.A., Stueckle, T.A., Tse, W., Rojanasakul, Y. and Dinu, C.Z. (2012) Digitoxin and its analogs as novel cancer therapeutics. *Exp. Hematol. Oncol.* 1, 4.

56. Tahervand, A., Parnian, B., Roudkenar, M.H. and Roushandeh, A.M. (2017) Digoxin effectively inhibited cell growth and induced senescence in cervical cancer cell line. Gene Cell Tiss. **4**(2), e14216

57. Kaushik, U., Aeri, V. and Mir, S.R. (2015) Cucurbitacins – An insight into medicinal leads from nature. *Pharmacog. Rev.* **9**(17), 12-18

58. Piironen, V., Toivo, J., Puupponen-Pimiä, R. and Lampi, A.M. (2003) Plant sterols in vegetables, fruits and berries. *J. Sci. Food Agric.* **83**, 330-337.

59. Suttiarporn, P., Chumpolsri, W., Mahatheeranont, S., Luangkamin, S., Teepsawang, S. and Leardkamolkarn, V. (2015) Structures of phytosterols and triterpenoids with potential anti-cancer activity in bran of black non-glutinous rice. *Nutrients* **7**, 1672-1687

60. Bin Sayeed, M.S., Karim, S.M.R., Sharmin, T. and Morshed, M.M. (2016) Critical analysis on characterization, systemic effect, and therapeutic potential of beta-sitosterol: A plant-derived orphan phytosterol. *Medicines* **3**, 29

61. Saeidnia, S., Manayi, A., Gohari, A.R. and Abdollahi, M. (2014) The story of beta-sitosterol - A review. *Eur. J. Med. Plants* **4**(5), 590-609.

62. Choi, J.M., Lee, E.O., Lee, H.J., Kim, K.H., Ahn, K.S., Shim, B.S, Kim, N.I., Song, M.C., Baek, N.I. and Kim, S.-H. (2007) Identification of campesterol from *Chrysanthemum coronarium* L. and its antiangiogenic activities. *Phytother. Res.* **21**(10), 954-959

63. Tavakoli, J. and Sorbi, N. (2017) Fortification of refined soybean oil by hull oil of two Iranian wild pistachios: Improving thermal stability during frying process. *Intern. J. Food Properties* **20**(Suppl 3), S2990-S3003

64. Pawar, H.A., Shenoy, A.V., Narawade, P.D., Soni, P.Y., Shanbhag, P.P. and Rajal, V.A. (2011) Preservatives from nature: A review. *Intern. J. Pharmaceut. Phytopharmacol. Res.* **1**, 78-88

65. Cheesman, L., Nair, J.J. and van Staden, J. (2012) Antibacterial activity of crinane alkaloids from *Boophone disticha* (Amaryllidaceae). *J. Ethnopharmacol.* **140**, 405-408.

66. Santos, F.A., Frota, J.T., Arruda, B.R., de Melo, T.S., da Silva, A.A.C.A., de Castro Brito, G.A., Chaves, M.H. and Rao, V.S. (2012) Antihyperglycemic and hypolipidemic effects of  $\alpha$ ,  $\beta$ -amyrin, a triterpenoid mixture from *Protium heptaphyllum* in mice. *Lipids Health Dis.* **11**, 98

67. Vázquez, L.H., Palazon, J. and Navarro-Ocaña, A. (2012) The pentacyclic triterpenes  $\alpha$ ,β-amyrins: A review of sources and biological activities. In: Venketeshwer Rao (Ed). *Phytochemicals - A Global Perspective of Their Role in Nutrition and Health*. InTech, Croatia, pp. 487-502.

68. Nogueira, A.O., Oliveira, Y.I.S., Adjafre, B.L., de Moraes, M.E.A. and Aragão, G.F. (2019) Pharmacological effects of the isomeric mixture of alpha and beta amyrin from *Protium heptaphyllum*: a literature review. *Fund. Clin. Pharmacol.* **33**, 4-12

69. Na, M., Kim, B.Y., Osada, H. and Ahn, J.S. (2009) Inhibition of protein tyrosine phosphatase 1B by lupeol and lupenone isolated from Sorbus commixta. *J. Enzyme Inhibit. Med. Chem.* **24**(4), 1056-1059

70. Wal, P., Wal, A., Sharma, G. and Rai, A.K. (2011) Biological activities of lupeol. *Syst. Rev. Pharm.* **2**(2), 96-103