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Effect of processing methods on nutritional composition, phytochemicals, and anti-nutrient properties of chaya leaf (*Cnidoscolus aconitifolius*)

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Nutritional composition, phytochemical and anti-nutrient properties in blanched, boiled, leaves extract, and its residues respectively of *Cnidoscolus aconitifolius*, were determined using standard analytical methods. The moisture content significantly differed, with its values ranging from 89.30±0.21% in fresh leaves to 68.10±0.02% in leaf residue; the leave extract had the highest protein content (3.76±0.06%). There was no significant difference in the fat content of the blanched and boiled leave samples (0.30±0.00%), and the ash content significantly decreased. Leaves residue after extraction had the highest energy value (89.79), carbohydrate content (22.96±0.03%), and fibre content (4.07±0.05%). Alkaloids and flavonoids content significantly ($p<0.05$) decreased from 108.33 and 260.00 mg/100 g, respectively in freshly harvested leaves to 83.33 in boiled leaves and 183.33 mg/100 g in the leaves extract, respectively. Carotenoids and oxalate significantly decreased from 1906.67 µg/100 g and 78.33 mg/100 g in freshly harvested leaves to 1840.00 µg/100 g and 31.67 mg/100 g in blanched leaves and leaves residue after extraction, respectively. Boiling increased the saponin content to 243.33 mg/100 g from 225.00 mg/100 g in fresh leaves. Phytate and tannin decreased significantly ($p<0.05$) from 50.00 and 66.67 mg/100 g, in fresh leaves to 15.33 and 19.33 mg/100 g in boiled leaves, respectively. It would be a rich source of nutrients and phytochemicals, if it is well processed to reduce its anti-nutritional content.

Key words: nutrients, phytochemical, antinutrients, processing method, *Cnidoscolus aconitifolius.*

INTRODUCTION

Vegetables form an important part of human diet and are always regarded as food. The importance and awareness of nutrient in public health issues have resulted in the increase demand of knowledge of the nutrient in vegetables (Chima and Igyor, 2007).

Awareness of the significance of vegetable consumption plays an important role in maintaining good health, and in reducing the risk of illness (Kalt, 2005). Its

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consumption plays a significant role in human nutrition especially as a source of carotene, ascorbic acid, riboflavin, folic acid (vitamin B9), and minerals like calcium, phosphorus, potassium and iron (Fasuyi, 2006), and it also, contains some phytochemical compound which serves as valuable antioxidant and protectant to the body system of man when consumed.

One of the under-utilized plant genera is chaya leaf (*Cnidoscodus aconitifolius*), an herbaceous plant belonging to the family, Euphorbiaceae with green or dark green leaves. It is broadly distributed throughout the tropics and can be found throughout Nigeria, East Africa particularly in Kenya. It is an evergreen drought deciduous shrub up to 6 m in height with alternate pinnate lobed leaves, milky sap and small flowers on dichotomously branched cymes. The leaves are large, 32 cm long and 30 cm wide on chartacious and succulent petioles (Fagbohun et al., 2012; Mordi and Akanji, 2012). In the western part of Nigeria it is called different names such as Efo Iyana-Ipaja and Efo Jerusalem, while in the Niger Delta of Nigeria; it has been nick-named “Hospital Too Far” because of its numerous health benefits. Mordi and Akanji (2012) reported that vegetables which contain a number of phytochemicals with reduce anti-nutrients exalt health promoting effect.

Although the plant is mainly cultivated as food, but it has continued to be an important medicinal plant. Much of its recent spread into new areas may likely be attributed to its medicinal value. A wide variety of claims have been made for its medicinal efficacy as a treatment for numerous ailments ranging from its ability to strengthen fingernails and darken grey hair to cure for alcoholism, insomnia, gout, scorpion stings, brain and vision improvement (Mordi and Akanji, 2012). Fagbohun et al. (2012) reported that its leaves and shoot are taken as laxative, diuretic, circulatory stimulants, and also, to stimulate lactation.

Phytochemical are suggested to be the major bioactive compound contributing to the health benefit of most vegetables, while anti-nutrients in vegetables interfere with nutrient absorption in the body. Most of the data available on nutritional status of some tropical Africa green leafy vegetable focused on the effect of blanching on the nutrient, antinutrient and antioxidant content of the commonly consumed tropical vegetable (Oboh, 2005a, b), and also on the effect of storage temperature of these vegetables (Adetuyi et al. 2009). The full benefits of this vegetable has not been harnessed because of the presence of inherent toxic components in the plant (Fasuyi and Aletor, 2005; Shittu et al. 2014). Thus, the effect of processing methods on its nutritional composition, phytochemicals and anti-nutrient properties will aid its recommendation to the populace, and justify its consumption.

This present study was thereby aimed at determining the effect of processing methods on the nutritional composition, phytochemicals and anti-nutritional content of *C. aconitifolius* leaves.

MATERIALS AND METHODS

Plant materials

Fresh sample of *C.aconitifolius* were collected from a garden in Otun Community, Saki, Oyo State, Nigeria. Botanical identification was carried out at the herbarium (FHI) Forestry Research Institute of Nigeria, Ibadan, Oyo state Nigeria.

Preparation of plant materials

The fresh leaves of *C. aconitifolius* were thoroughly cleansed and were divided into four portions. Portion of the leaves were water blanched at 65°-C for 10 min, boiled at 100□C for 15 min, leaves juice was extracted from a portion, and the residue after extraction of juice were analysed, respectively. The freshly harvested leaves were used as the control.

Determination of nutritional composition

The recommended methods of the Association of Official Analytical Chemicals (AOAC, 2005) were used for the determination of moisture, ash, crude fibre and protein content, and mineral. Carbohydrate was calculated by difference as the sum of the moisture, fat, protein and ash contents were subtracted from 100 as outlined in AOAC (2005). The sample calorific value was estimated (in kcal) by multiplying the percentages of crude protein, crude lipid and carbohydrate by the recommended factors (2.44, 8.37, and 3.47, respectively) as used in vegetables analysis by Asibey-Berko and Tayie, (1999).

Determination of antinutritional and phytochemical composition of *C. aconitifolius* leaves sample

The methods described by Ijarotimi et al. (2013) and Oladele et al. (2009) were adopted for the determination of alkaloid, oxalate, phytate, saponins, tannin, total flavonoid, and phenolic compounds.

Statistical analysis

Quantitative data were expressed as means and standard deviation (SD) of at least three measurements. Each experimental set was compared with one way analysis of variance (ANOVA) procedure using Statistical Package for Social Sciences (SPSS) version 11.5 (SPSS Inc., Chicago, IL, USA). Duncan’s new multiple range test was used to determine the differences of means. P values <0.05 were regard as significant.

RESULTS AND DISCUSSION

Proximate composition of *C. aconitifolius* leaves

The proximate composition of *C. aconitifolius* is shown in Table 1. The availability of moisture in vegetables determines its freshness. The moisture content obtained in this study significantly differed, with its values ranging from 89.30±0.21% in fresh leaves to 83.90±0.20,

Table 1. The proximate composition (%) and energy value in (kcal) of chaya leaf.

Nutrient	Fresh leaves	Blanched leaves	Boiled leaves	Leaves extract	Leaves residue
Moisture (%)	86.30±0.20^{d}	82.40±0.20^{b}	83.90±0.20^{bc}	89.30±0.21^{e}	68.10±0.02^{a}
Protein (%)	3.60±0.05^{d}	3.20±0.10^{b}	3.50±0.05^{c}	3.76±0.06^{e}	2.57±0.20^{a}
Fat (%)	0.47±0.05^{d}	0.30±0.00^{c}	0.30±0.05^{c}	0.23±0.05^{b}	0.10±0.00^{a}
Ash (%)	2.67±0.20^{d}	2.20±0.12^{b}	2.50±0.03^{c}	1.70±0.05^{a}	2.20±0.05^{b}
Fibre (%)	2.20±0.10^{c}	1.90±0.05^{b}	1.90±0.05^{b}	0.13±0.05^{a}	4.07±0.05^{d}
Carbohydrates (%)	4.00±0.10	10.00±0.05	9.90±0.05	4.88±0.04	22.96±0.03
Energy value (kcal)	40.69^{b}	44.02^{c}	54.40^{d}	34.93^{a}	89.79^{e}

Values are means ±standard deviation (SD) of triplicate samples; means with different superscripts in the same row were significantly different (P< 0.05).

Table 2. Mineral composition of *Cnidoscolus aconitifolius* leaves in mg/100 g.

Nutrients	Fresh leaves	Boiled leaves	Blanched leaves	Leaves extract	Leaves residue
Calcium	218.30±0.20^{e}	158.40±0.20^{b}	174.00±0.20^{d}	168.30±0.21^{c}	60.20±0.02^{a}
Iron	8.17±0.05^{d}	6.47±0.10^{c}	6.97±0.05^{c}	5.67±0.06^{b}	4.10±0.20^{a}
Magnesium	53.00±0.05^{e}	50.30±0.00^{d}	45.00±0.05^{c}	35.23±0.05^{b}	25.00±0.00^{a}
Phosphorus	155.00±0.20^{e}	135.00±0.12^{c}	115.00±0.03^{b}	140.00±0.05^{d}	65.67±0.05^{a}

Values are means ±standard deviation (SD) of triplicate samples; means with different superscripts in the same row were significantly different (P< 0.05).

82.40±0.20, and 68.10±0.02% in boiled, blanched leaves, and leaf residue, respectively. Moisture was determined as total solid in the leaves extract which gave datum of 86.30±0.20%. The values obtained in this study are similar to the data obtained for other leafy vegetables as reported by Oduse et al. (2012). There was significant difference in the protein content of the leave samples. The leave extract had the highest value (3.76±0.06%), which may be attributed to the solubility of protein in water. Fresh, boiled, blanched sample, and leaf residue had 3.60±0.05, 3.50±0.05, 3.20±0.10, and 2.57±0.20%, respectively. The report of this study is similar to that reported by Gupta et al. (2004) and Oduse et al. (2012) for leafy green vegetables, respectively.

Fat content of fresh, blanched, boiled leaves, leave extract, and leave residue were 0.47±0.05, 0.30±0.00, 0.30±0.05, 0.23±0.05, 0.10±0.00%, respectively. This vegetable is highly palatable, since fat increased the palatability of food by absorbing and retaining flavours.

The ash content significantly decreased from 2.67±0.20% in fresh leaves to 2.50±0.03, 2.20±0.12, 1.70±0.05, and 2.20±0.05% in boiled, blanched leaves, leave extract, and leaf residue after extraction, respectively.

The fibre content of the leaf residue after extraction was the highest (4.07±0.05%), while there were no significant difference in the values obtained for blanched and boiled leaves (1.90±0.05%), respectively. The fibre content of the leaf extract (0.13±0.05%) was the lowest.

The carbohydrate content for the leaf residue (22.96±0.03%) was the highest while fresh leaves and leaf extract showed the lowest value (4.00±0.10 and 4.88±0.04%), respectively. The result of research work is similar to that reported by Gupta et al. (2004). Leaves residue after extraction had the highest energy value (89.79) followed by boiled leaves (54.40). The leaf extract had the lowest (34.93). Blanched and fresh leaves had 40.69 and 44.02, respectively. Dietary fibre reduced serum cholesterol level, hypertension, and diabetes.

Mineral composition

The mineral composition of *C. aconitifolius* leaves is as shown in Table 2. The calcium content ranged from 218.30±0.20 mg/100 g in fresh leaves to 60.20±0.02 mg/100 g in the leaves residue after extraction. Processing methods; blanching, boiling, and extraction of the juice significantly (p≤0.05) decreased the calcium content of the leaves to 174.00±0.20, 158.40±0.20, 168.30±0.21 mg/100 g, respectively. The calcium content of freshly harvested *C. aconitifolius* obtained in this study is greater than that reported for freshly harvested leafy vegetables; Yanrin (120.00±0.74 mg/100 g), Ewuro odu (98.00±0.00 mg/100 g), Efinrin (89.00±0.33 mg/100 g) by Oduse et al. (2012), and the prior data obtained for *C. aconitifolius* (63.00±0.49 mg/100g) by Aye (2012), and that of Soko (188.00±0.00 mg/100 g) as reported by Gupta et al. (2004). The report of this study showed that consumption of this vegetable would supply adequate

Table 3. Antinutrients composition (mg/100 g) of fresh and processed leaves of *Cnidoscolus aconitifolius.*

Anti-nutrient	Fresh leaves	Blanched leaves	Boiled leaves	Leaves extract	Leaves residue
Oxalate	78.33±2.89[e]	35.00±0.00[b]	53.33±2.89[d]	45.00±0.00[c]	31.67±2.89[a]
Phytate	50.00±0.00[e]	15.33±0.58[c]	24.00±1.73[d]	12.00±0.00[b]	8.00±0.00[a]
Tannin	66.67±2.89[e]	19.33±1.15[a]	25.00±0.00[bc]	30.00±0.00[d]	21.66±0.58[b]

Values are means ±standard deviation (SD) of triplicate samples; means with different superscripts in the same row were significantly different (P< 0.05).

amount of calcium needed by the body, to play a part in muscle contraction and relaxation, blood clotting, synaptic transmission and absorption of vitamin B12 in the body.

The iron content significantly decreased from 8.17±0.05 to 6.97±0.05 mg/100 g, 6.47±0.10 mg/100 g, and 4.10±0.20 mg/100 g in boiled, blanched leaves, leave extract, and leaves residue, respectively. The data obtained in this study is similar to that reported by Oduse et al. (2012) for yanrin (5.26±0.00), ewuro odu (7.03±0.00), ebolo (6.50±0.00), Efinrin (4.20±0.00) but greater than that reported for chaya leaf (0.03±6.10 mg/100 g) and water leaf (0.39±0.00 mg/100 g) by Adanlawo and Elekofehinti (2012) and Fasuyi (2006), respectively. Iron is essential for haemoglobin formation, normal functioning of the central nervous system and in the oxidation of carbohydrates, protein and fats.

Magnesium and phosphorus also decreased as a result of processing; boiling, blanching, and extraction. Magnesium decreased from 53.00±0.05 mg/100 g in fresh leaf to 25.00±0.00 mg/100 g in leaf residue after extraction. The data obtained for phosphate in this study were 155.00±0.20, 140.00±0.05, 135.00±0.12, 115.00±0.03, and 65.67±0.05 mg/100 g for fresh, leaves extract, boiled, blanched leaves, and leaf residue after extraction, respectively. The data obtained in this study is similar to that reported for *Ceratitheca sesamoides* (115.67 mg/100 g), but higher than that reported for *Crassocephalum crepidioides* (2.33 mg/100 g) and *Vernonia amygdalina* (33.6 mg/100 g) by Oduse et al. (2012).

Antinutrients and phytochemical composition of *C. aconitifolius* leaves

The antinutritional components of blanched and boiled leaves, extracted juice from leaf of *C. aconitifolius,* and the leaves residue after extraction is presented in Table 3. The oxalate content of *C. acontifolius* decreased significantly to 31.67± 2.2.89 mg/100 g in leaves residue after extraction from 79.33± 2.89 mg/100 g in the fresh sample. The blanched, sapped, and boiled samples contained 53.33±2.89, 45.00±0.00, and 35.00±0.00 mg/100 g, respectively. This showed that application of heat significantly (p<0.05) reduced the total content of oxalate in the leaf. The report of this research work is similar to the findings of Sheeta et al. (2004), but higher than that reported by Aye, (2012) when he studied the effect of sun drying on the oxalate content of chaya leaves. Therefore, boiling significantly reduced the oxalate content of vegetables. Oxalate is known to interfere with calcium absorption by forming insoluble salt of calcium. This insoluble salt of calcium is capable of passing through the excretory system and interrupts with the efficient working of the kidney, otherwise causes a disease called kidney stone (Sheetal et al., 2004). Phytate chelates minerals in the body. Thus, makes certain important minerals such as zinc, iron and to a lesser extent mineral such as calcium and magnesium biologically unavailable in the body (Mullaney and Ullah, 2012). Its content significantly decreased from 50.00±0.00 mg/100 g in fresh leaves to 15.33±0.58in boiled leaves which is in agreement with the report of Bawa and Yadav (1986), who also reported a decreased in the phytate content of *C. aconitifolius* to 12.5 and 18.75 mg/100 g in boiled leaves. The leaves extract, blanched leaves, and the remains after extraction contained 12.00±0.00, 24.00±1.73, 8.66±0.00 mg/100 g, respectively. Tannins content decreased from 66.67±2.89 in fresh leaves to 19.33±1.15 mg/100 g in boiled leaves. The leaves extract, blanched, and the remains after extraction contained 30.00±0.00, 25.00±0.00 and 21.66±0.58 mg/100 g, respectively. The presence of tannin in vegetables suggests the ability of the plant to help as antioxidant and antihaemorrhoidal agent (Asquith and Butter, 1986).

The phytochemical component of blanched and boiled leaves, extracted juice from leaf of *C. aconitifolius,* and the leaves residue after extraction is presented in Table 4. The alkaloids content of *C. aconitifolius* decreased from 108.33±2.89 mg/100 g in fresh leaves to 95.00±0.00, 90.00±0.00, 83.33±2.89, and 12.67±1.15 mg/100 g, in blanched, boiled, sapped and the solid remain of the leaf sample, respectively. Ekeleme et al. (2013) reported that alkaloids are effective for its detoxifying and antihypertensive properties. The carotenoid content obtained in this study ranged from 225.00±0.00 mg/100 g in leaves sample after extraction to 1650±0.00, 1746.67±5.77, 1906.67±5.77 and 1840.00±13.23 mg/100 g, in leaves extract, boiled, blanched, and fresh leaves, respectively. The report of

Table 4. Phytochemicals composition of fresh and processed leaves of *Cnidoscolus aconitifolius.*

Phytochemical	Fresh	Boiled	Blanched	Leaves extract	Leaves residue
Alkaloids (mg/100 g)	108.33±2.8[e]	83.33±2.89[b]	95.00±0.00[d]	90.00±0.00[c]	12.67±1.15[a]
Carotenoids (mg/100 g)	1906.6±5.77[e]	1746.67±5.77[c]	1840.00±13.23[d]	1650.00±0.00[b]	225.00±0.00[a]
Flavonoids (mg/100 g)	260.00±0.00[e]	243.33±2.89[c]	255.00±0.00[d]	183.33±2.89[b]	63.33±2.89[a]
Phenolic (GAE/100 g)	25.50±0.87[e]	12.17±0.29[b]	17.17±0.58[d]	15.17±0.29[c]	7.83±0.29[a]
Saponin (mg/100 g)	225.00±0.00[c]	243.33±2.89[d]	225.0±0.00[c]	181.67±2.89[b]	61.67±2.89[a]

Values are means ±standard deviation (SD) of triplicate samples; means with different superscripts in the same row were significantly different (P< 0.05).

this research work indicated that carotenoid is highly resistant to heat processing. Flavonoids content ranged from 63.33±2.89 to 183.33±2.89, 243.33±2.89, 255±0.00, and 260.00±0.00 mg/100 g, in the leaves remain after extraction, extracted juice, boiled, blanched and fresh vegetables, respectively. Cushnie and Lamb (2005) reported that it modifies the body's reaction to allergens, viruses and carcinogens by exhibiting anti-inflammatory and antimicrobial activity. The presence of phenolic at garlic acid equivalent/100 g decreased from 25.50±0.87GAE/100 g in fresh samples to 12.17±0.29 and 7.83±0.29 GAE/100 g in boiled and leaves remains after extraction, respectively. The phenolic content of blanched leaves and sapped content were 17.17±0.58 and 15.17±0.29 GAE/100 g, respectively. Similar data were reported by Adeniji et al. (2007) when they worked on heavy metals and antinutrients in banana and plantain cultivars. Saponin increased from 225.00± 0.00 mg/100 g in freshly harvested and blanched leaves to 243.33±2.89 mg/100 g in boiled leaves. It significantly decreased in the leaves residues after extraction to 61.67±2.89 mg/100 g. Fagbohun et al. (2012) reported that it had anti-hypercholesterol, anti-inflammatory, cardiac depressant properties, and appears to inhibit cancer cells without destroying the normal cells.

Conclusion

It could be concluded that freshly harvested leaves contained all nutrients (macronutrients and mineral) in adequate quantity needed by the body, except for the leaf residue after extraction which is highly rich in fibre (4.07±0.05%), and leaf extract which had highest protein content (4.07±0.05%). Boiling as a pre-treatment method for *C. aconitifolius* significantly increased the saponin contents of the leaf to 243.33 from 225 mg/100 g in fresh leaves, while other processing methods; blanching, and extraction of juice from the leaf, respectively decreased other phytochemicals present in the leaves. The leaves should not be over-cooked. Oxalate, phytates, and tannin were significantly reduced as a result of processing such as blanching, boiling, and extraction of the leaves juice from the leaves. However, pre-treating this vegetable would greatly decreased the antinutrients in it.

Conflict of interests

The authors did not declare any conflict of interest.

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