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Original Article

Evaluation of some edible leaves as potential feed ingredients in aquatic animal nutrition and health

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Abstract

In this study, the potential benefits of ten edible leaves (*Manihot esculents*, cassava leaf; *Colocasia esculenta*, cocoyam leaf; *Talinum triagulare*, water leaf; *Telfairia occidentalis*, fluted pumpkin leaf; *Carica papaya*, pawpaw leaf; *Amaranthus chlorostachys*, green leaf; *Moringa oleifare*, drumstick leaf; *Vernonia amygdalina*, bitter leaf; *Ipomoea batatas*, sweet potato leaf and *Basella alba*, Malabar spinach 'Amunututu' to aquatic animal nutrition and health were studied along with proximate, mineral and phytochemical compositions. Results show that theses edible leaves were a good source of protein and the highest crude protein was obtained in *C. papaya* (32.6%) while the lowest in *C. esculenta* (14.7%). The highest and lowest total ash was found in *T. triagulare* (34.6%) and *C. papaya* (11%) respectively. The result showed that the edible leaves are rich in wide variety of secondary metabolites of phytochemical constituents such as tannins, alkaloids, flavonoids, saponins, glycosides oxalates and phytate which can act against different diseases. Results suggest that inclusion of edible leaves may be nutritionally beneficial and this could promote growth, immune system and enhance disease resistance properties and subsequently very potential to reduce the cost of highly priced supplementary feeds.

Keywords: Edible leaves; proximate composition; minerals; animal nutrition; phytochemical; fish feed

1 | INTRODUCTION

The increasing cost of feed stuffs in animal production have been identified as a serious impediment in meeting the demand for animal protein particularly in developing countries (Adejinmi *et al.* 2000; Hossain *et al.* 2009; Mohsin *et al.* 2012a, 2012b). However, the ever-increasing cost of animal feeds makes it necessary to explore the use of alternative feed ingredients that are cheaper, locally available and of low human preference (Agbede *et al.* 2002; Tuleun *et al.* 2009; Kamal *et al.* 2010; Galib *et al.* 2013; Asadujjaman and Hossain 2016) such alternatives include the uses of edible leaves (vegetables). Vegetables are rich sources of vital ingredients in healthy and balanced human and animal diets without quantitative restriction (Aletor and Adeogun 1995; Okoli *et al.* 1998; Osuagwe 2008).

They are important low cost foods containing low levels of fat and high levels of vitamins, minerals, fibre and

some calorie intake and protein (Oguntona 1998; Mepba *et al.* 2007; Bolaji *et al.* 2008). Leafy vegetables which are fed either as processed, semi processed or fresh to man but usually fresh to livestock are reported to be a good source of carotene, ascorbic acid, riboflavin, folic acid and minerals like calcium, iron and phosphorus which have several health benefits including therapeutic uses (Fasuyi 2006; Islam *et al.* 2013; Galib *et al.* 2016). Protein from plant leaves sources is perhaps the most naturally abundant and the cheapest potential source of protein. Natural resources are available for the synthesis and polymerization of amino acids into less mobile forms and stored as such in plant leaves (Fasuyi and Nonyerem 2007).

The utilization of plant and leaf extracts in animal production has found widespread scientific and commercial acceptance as a strategy to improve the health status and performance of the animals (Djakalia *et al.* 2011; Ugwu *et al.* 2011). Leafy vegetables are known to add taste, flavour, as well as substantial amounts of protein, fibre, minerals and vitamins to the diet (Oyenuga and Fetuga 1975; Adeyemi 1987). The amounts of the nutrients constituents in the more commonly used leafy vegetable species in Nigeria have been studied to some extents (e.g. Oyenuga 1968; Kola 2004), the lesser known regional and local species remain virtually neglected. Lack of information on the specific nutrients in a large number of the native vegetables species with which Nigeria is richly endowed is partly responsible for their under-exploitation especially in areas beyond the traditional localities where they are found and consumed.

Also, utilization of plant as protein source in animal feed depends not only on their nutritional content, but also on the presence and level of various toxic constituents (anti-nutritional factors) and method of detoxification. These anti-nutritional factors have serious implication on the performance and health status of animals when considerable amounts are ingested in feed. They include tannins, hydrocyanic acids, oxalates, saponins, phenolic acids, glycosides, flavonoids etc. Hence, this study determined the proximate composition, minerals, phytochemical and investigates its suitability as alternative feed ingredients for aquatic and terrestrial animal production.

2 | METHODOLOGY

2.1 | Plant leaves collection and identification

The edible leaves were collected on the 2nd of December, 2013 from the Nursery and Wood Processing Units of the Department of Forest Resources Management, University of Ibadan, Nigeria. They were identified at the herbarium of the Forestry Research Institute of Nigeria (FRIN), Ibadan, where a voucher specimen was deposited (voucher number FHI 107515).

2.2 | Plant leaves preparation

The plants were washed with distilled water and allowed to air dry at room or ambient temperature for two weeks. The leaves (200 g) were blended into fine powder and stored in air tight container until required.

2.3 | Analytical methods

Each sample of the edible leaves was replicated thrice and analysed for their proximate composition according to the methods of Association of Official Analytical Chemists (AOAC 2005).

2.4 | Determination of the minerals

Each of the edible leaves (10 g) was ashed (dry ashing) at 550 ^{o}C for 6 hours in an electric muffle then diluted in 5 ml of 10% HCl. This was filtered and made up to the mark in 50 ml volumetric flask, the filtrate was used for the analysis and this was carried out at the Department of Aquaculture and Fisheries Management, University of Ibadan, Nigeria from January to March, 2014 in Atomic absorption/emission spectrophotometer (Buck Scientific, model 200-A) for calcium and iron while phosphorus was determined by the use of the UV visible spectrometer following Nwanna and Olusola (2014).

2.5 | Determination of phytochemical in edible leaves

Phytochemical tests for bioactive constituents were carried out on portions of the residual material using standard phytochemical procedures:

Colour tests for alkaloids: 500 mg of plant material was extracted with 500 ml of methanol for 20 minutes, on a water bath. The extract was then filtered off and allowed to cool. This extract was dispensed in 2 ml of portions into four different test tubes. Either the Dragendorff's or Hager's or Mayer's or Wagner's alkaloidal reagent was added to each tube and the presence or absence of colours of any precipitates was noted in each test tube.

Frothing test for saponins: Water extract was obtained by boiling on the water bath. The extract was transferred into a test tube and shaken vigorously then was left to stand for 10 minutes and the result noted. A thick persistent froth indicates saponins.

Ferric chloride solution test for tannins: Water extract was treated with 15% ferric chloride test solution. The resultant colour was noted. A blue colour indicates condensed tannins, a green colour indicated hydrolysable tannins.

Test for flavonoids: Water extract of the sample was reduced to dryness on the boiling water bath. The residue was treated with diluted NaOH, followed by addition of

dilute HCl, solubility and colour was noted. A yellow solution with NaOH, which turns colourless with diluted HCl confirm flavonoids.

Borntrager's test for anthraquinone derivatives: Chloroform extract of the material was obtained by boiling on the water bath. To 2 ml of this extract, 1 ml of dilute (10%) ammonia was added and the mixture was shaken. Any colour change was recorded. A pink-red colour in the ammoniacal (lower) layer shows anthracene derivatives.

Fehling's test for reducing sugars (in glycosides): The residue was re-dissolved in water on the water bath. To 2 ml of the solution, in the test tube was added, 1 ml each of Fehling's solutions A and B. The mixture was shaken and heated in a water bath for 10 minutes. The colour obtained was recorded. A brick-red precipitate indicates reducing sugar.

2.6 | Statistical analysis

Proximate composition of the edible leaves and minerals resulting from the experiment were subjected to one-way analysis of variance (ANOVA) using SPSS (Statistical Package for Social Sciences, version 15.0). Duncan new multiple range test was used to separate means of significant treatment (p = 0.05).

3 | RESULTS

3.1 | Proximate composition

The proximate composition of studied edible leaves showed the highest dry matter in *M. oleifera* and the lowest in *C. esculenta*, the highest and lowest crude protein was recorded in *C. papaya* and *M. esculents* respectively. The highest and lowest ash contents were recorded in *T. triagulare* and *C. papaya* respectively. All these varied significantly (p < 0.05) among leaf types. The highest and lowest ether extract was obtained in *T. occidentalis* and *T. triagulare* respectively. Crude fibre was the highest in *M. oleifare* and the lowest in *A. chlorostachys*, which also varied significantly (p < 0.05) among leaves. The nitrogen free extract (NFE) was highest in *I. batatas* and lowest in *M. oleifare* (Table 1).

TABLE 1 Chemical composition of studied leaves (as percentage of dry matter; Mean ± SD, N = 3)

Leaves	*Dry matter*	*Crude protein*	*Ether extract*	*Crude fibre*	*Ash*	*NFE*
Manihot esculents (Cassava leaf)	25.60±0.00^{i}	14.69±0.01^{a}	8.90±0.02^{g}	15.63±0.03^{e}	16.07±0.02^{g}	45.22±0.03^{h}
Colocasia esculenta (Cocoyam leaf)	8.23±0.02^{a}	24.95±0.04^{g}	10.66±0.01^{h}	12.08±0.05^{d}	12.42±0.02^{d}	39.89±0.01^{d}
Talinum triagulare (Water leaf)	9.68±0.04^{b}	21.09±0.05^{c}	1.47±0.06^{b}	10.34±0.01^{d}	34.56±0.01^{j}	32.54±0.02^{b}
Telfairia occidentalis (Fluted pumpkin leaf)	13.63±0.03^{f}	21.17±0.05^{d}	12.94±0.07^{i}	12.79±0.08^{d}	13.86±0.02^{f}	39.24±0.04^{c}
Carica papaya (Pawpaw leaf)	24.60±0.00^{h}	32.60±0.08^{j}	0.80±0.01^{a}	7.30±0.04^{a}	11.00±0.03^{a}	48.30±0.05^{i}
Amaranthus chlorostachys (Green leaf)	11.40±0.06^{d}	26.30±0.02^{h}	5.30±0.00^{f}	8.80±0.03^{b}	19.30±0.05^{h}	40.30±0.09^{e}
Moringa oleifare(Drumstick leaves)	88.62±0.05^{j}	26.62±0.02^{i}	5.34±0.06^{f}	18.97±0.01^{f}	12.01±0.10^{c}	25.68±0.03^{a}
Vernonia amygdalina (bitter leaf)	21.20±0.03^{g}	19.70±0.01^{b}	4.50±0.01^{e}	18.95±0.05^{f}	12.85±0.08^{e}	44.00±1.05^{g}
*Ipomoea batatas (*Sweet potato leaf)	12.45±0.05^{e}	24.65±0.01^{f}	3.58±0.03^{c}	9.10±0.02^{bc}	11.47±0.05^{b}	51.20±0.01^{j}
Basella alba (Malabar spinach)	9.80±0.02^{c}	22.10±0.00^{e}	3.80±0.01^{d}	10.35±0.05^{c}	20.50±0.02^{i}	43.25±0.08^{f}

NFE, Nitrogen Free Extract; mean values in each row with similar superscripts are not significantly different (p > 0.05)

3.2 | Mineral composition

The mineral composition of studied leaves is presented in Table 2. The highest calcium was recorded in *M. oleifare* and lowest in *T. occidentalis* (Table 2). The highest and lowest phosphorus were recorded in *M. oleifare* and *B. alba* respectively and varied significantly (p < 0.05) among leaf types. The highest iron and calcium/phosphorus ratio was obtained in *V. amygdalina* and *M. oleifare* respectively which also varied significantly (p < 0.05; Table 2).

3.3 | Phytochemical properties

Preliminary phytochemical screening of studied edible leaves for secondary metabolites showed the presence of saponins, tannins, alkaloids, oxalates, glycosides, phytate and flavonoids. The values of these metabolites were in higher quality (+++), moderate quality (++) and small quality (+). However, some phytochemical were not detected in some of these leaves (Table 3).

4 | DISCUSSION

Minerals are required for normal growth, activities of muscles and skeletal development (such as calcium), cellular activity and oxygen transport (iron), and the regulation of acid-base balance (phosphorus). Iron is useful in prevention of anemia and other related diseases (Oluyemi *et al.* 2006). Deficiency of these nutrients and minerals are known to affect the performance and health of animals (Merck 2005).

TABLE 2 Minerals content and calcium/phosphorus ratio of studied leaves (mg 100 g^{-1} food; *N* = 3)

Leaves	*Calcium*	*Phosphorus*	*Iron*	*Ca:P ratio*
Manihot esculents (Cassava leaf)	39.00±0.03^{d}	22.00±0.01^{e}	2.02±0.00^{c}	1.80±0.02^{b}
Colocasia esculenta (Cocoyam leaf)	409.00±2.00^{i}	51.40±0.01^{i}	1.21±0.01^{b}	7.96±0.02^{i}
Talinum triagulare (Water leaf)	37.00±0.01^{c}	20.00±0.00^{c}	7.15±0.00^{i}	1.85±0.01^{b}
Telfairia occidentalis (Fluted pumpkin leaf)	28.00±0.05^{b}	21.00±0.02^{d}	6.90±0.01^{g}	1.33±0.00^{a}
Carica papaya (Pawpaw leaf)	58.60±0.01^{e}	26.30±0.04^{f}	0.31±0.02^{a}	2.23±0.02^{c}
Amaranthus chlorostachys (Green leaf)	190.00±0.02^{h}	39.00±0.01^{h}	4.60±0.02^{f}	4.87±0.03^{f}
Moringa oleifare(Drumstick leaves)	440.00±0.02^{j}	70.00±0.05^{j}	7.00±0.04^{h}	6.29±0.07^{h}
Vernonia amygdalina (bitter leaf)	97.00±0.03^{f}	18.00±0.01^{b}	7.50±0.03^{j}	5.39±0.01^{g}
*Ipomoea batatas (*Sweet potato leaf)	98.10±0.04^{g}	27.60±0.00^{g}	3.03±0.01^{d}	3.55±0.02^{d}
Basella alba (Malabar spinach)	15.00±0.01^{a}	4.00±0.01^{a}	4.50±0.00^{e}	3.75±0.01^{e}

Mean values in each row with similar superscripts are not significantly different (p > 0.05)

TABLE 3 Phytochemical properties of studied leaves

Leaves	*Tannin*	*Saponins*	*Cyanides*	*Oxalates*	*Phytate*	*Glycosides*	*Alkaloids*	*Flavonoids*
Manihot esculents (Cassava leaf)	+ + +	+	+ + +	+ +	+ +	+ +	+	ND
Colocasia esculenta (Cocoyam leaf)	+ + +	+ +	+ +	+ +	+ +	+ +	+ +	ND
Talinum triagulare (Water leaf)	+ +	+	ND	+	+	+	+	+
Telfairia occidentalis (Fluted pumpkin leaf)	+ +	+ +	+ +	+ +	+	ND	+	+ +
Carica papaya (Pawpaw leaf)	+ +	+ +	+ +	+ +	+ +	+ +	+ +	+
Amaranthus chlorostachys (Green leaf)	+ +	+ +	+ +	+ +	+	+ +	+ +	ND
Moringa oleifare(Drumstick leaves)	+	+	ND	+	+	+	+	+
Vernonia amygdalina (bitter leaf)	+ +	+ +	+	ND	+	+ +	+ +	+ +
*Ipomoea batatas (*Sweet potato leaf)	+	+	+ +	+ + +	+	ND	+	ND
Basella alba (Malabar spinach)	+ +	+	ND	+ +	+	+ +	+ +	+

+, available in small quality; + +, available in moderate quality; + + +, available in high quality; ND, Not Detected

The presence of important nutrients like crude protein, crude fibre, low crude fat and fatty acid and high ash contents in all the studied leaves indicate that these leaves could be used as a nutritionally valuable and healthy ingredient to improve animal health and growth performance. However, there were variations in values of proximate composition of these plants when compared other findings (e.g. Idris 2011; Ogbe and Affiku 2011; Oluwalana *et al.* 2011). The differences in the composition may be due to the differences in the locality of its growth and the stage at maturity prior to harvesting.

Cassava leaf (*M. esculents*) is a significant source of potential alternative protein resource for both human and animals (Fasuyi 2005a). The results of this study showed high protein content and mineral composition which comply with Hidajat and Wargiono (2002) who reported that high protein content and nutritive value in cassava leaves may contribute to alleviate nutritional deficiency in poor countries. Also, cassava leaves could be a solution to micronutrient undernourishment due its high vitamin and mineral contents (Hidajat and Wargiono 2002).

Cocoyam leaves (*C. esculenta*) is an herbaceous plant which belongs to the family Araceae and its leaves are eaten as vegetable by human, having ß-carotene, iron, protein, vita-

mins and folic acid which protects against anemia (Sukamoto 2003). The results of proximate composition contrast to the report of Ogunlakin *et al.* (2012) whose values were lower than the one obtained in this study. Cocoyam leaves has been said to have the potential of being used in ruminant nutrition (Babayemi and Bankole 2009). It has been fed to snails (Okon *et al.* 2012), fish (Aderolu *et al.* 2009), pigs (Agwunobi *et al.* 2002) and poultry (Adejumo and Ologhobo 2012). Ndabikunze et al. (2011) reported high minerals value such as potassium, phosphorus, magnesium, and calcium in cocoyam leaves and this is in agreement with the present study. Phytochemical analysis revealed presence of some secondary metabolites that agrees with Olajide *et al.* (2011) that the use of cocoyam leaves in animal nutrition is, however, limited by the presence of anti- nutritional factors.

Water leaf (*T. triangulare*) is a common edible leafy vegetable, belonging to the family Portulacaceae. Different ethnic tribes in Nigeria referred to it as follows: Edos- Adodoro, Efik- Mmongikong, Igbo- Ntioke or Ofebekee, Tiv- Ashwe, Yoruba- Gbure and Yagbaland in Kogi State- Adegbere. The present results indicated that water leaf is a good source of protein and minerals. This agreed with the findings of Disu (2010) who reported that water leaf is eaten cooked as a pet-herb and in soups, as a condiment in sauces or raw in salad, besides, very rich in mineral salts and amino acids as well as having anti-scorbutic properties *i.e.* prevention against scurvy. Water leaf contains carotenoids such as lutein and zeaxanthin which act as a stimulant and in a way influencing the immune cells of the eyes (Shakuntala and Shadaksharaswamy 1985). Fasuyi (2005b) reported that consumption of vegetables such as water leaf helps toward off heart diseases, control blood pressure and cholesterol level, prevent some types of cancer, avoid a painful intestinal ailment called diverticulosis, and guard against cataract and muscular degeneration two common causes of vision loss.

Fluted pumpkin leaves (*T. occidentalis*) are a tropical vine grown in West Africa as a leafy vegetable and for its edible seeds. Common names for the plant include fluted gourd and fluted Pumpkin. It is known as 'Ugu' (Igbo language) in eastern parts of Nigeria. These leaves are sometimes called 'pumpkin leaves' in English. The plant is dioecious, perennial, and drought-tolerant. It is usually grown trellised. The young shots and leaves are the main ingredient of Nigerian 'edikang ikong soup'. The plant is cultivated for its edible seeds and young shoots and leaves. The seeds are cooked and eaten like beans and the shoots and leaves are eaten like vegetables. The results of the proximate composition of the present study are in agreement with Akoroda (1990) but contrast to Fasuyi and Nonyerem (2007) who reported higher values than the values found in the present study. Fluted pumpkin leaves are rich source of protein, oil, vitamin and minerals which enhances, nourish, protect, and heal the body. The presence of calcium, phosphorus and iron from the present study support the report of Ajibade *et al.* (2006) that the leaves are low in crude fibre but rich source of folic acid, calcium, zinc, potassium, cobalt, iron, vitamin A, C, and K. Consumption of the leaves assist to combat certain disease due to the presence of antioxidant and antimicrobial properties, its minerals (iron) vitamins (A and C) and high protein contents (Kayode and Kayode 2011).

Pawpaw (*C. Papaya*) leaves is a tropical herbacious plant. It bears fruits which may be yellowish green, yellow or orange in colour when ripe. Pawpaw is a powerhouse of nutrients and is available throughout the year. It is a rich source of threes powerful antioxidant vitamin C, vitamin A and vitamin E; the minerals, magnesium and potassium; the B vitamin pantothenic acid and folate and fibre (Aravind *et al.* 2013). The result of the study shows high protein source, crude fibre, ash and low fat which was in accord with the report of FAO (2001) that it contains appreciable amount of macro and micro nutrients required by animals for growth and development such as protein, carbohydrate, minerals, vitamins and fat content in little to no amount.

Amaranthus chlorostachys consists of hardy, weedy, herbaceous, fast-growing, cereal-like plants (Opute 1979) with a vegetable yield of 4.5 tons dry matter ha^{-1} after 4 weeks (Grubber and van Sloten 1981). This is one of those rare plants whose leaves are eaten as a vegetable while the seeds are used as cereals (Oke 1983). Amaranth leaves are combined with condiments to prepare soup in Nigeria (Oke 1983).

Drumstick leaf (*M. oleifera*) is a non- conventional plant with substantial nutritional value (Sanchez-Machado *et al.* 2010). It serves as a good source of protein, fat and an excellent source of calcium, iron or copper and zinc. Vitamin A is the most prominent vitamin essential for immune protection against all infections. It is a bio-enhancer of drug, and nutrient due to its antibiotic activity. The result of the study complies with Ferreira *et al.* (2008). It has nine essential amino acids that comprise the sulphur – containing amino acid methionine and costive (Makkar and Becker 1997) higher than levels recommended by the FAO (Ferreira *et al.* 2008). The leaves treat different ailments such as abnormal blood pressure, respiratory disorders, inflammation of mucous membranes, hepatitis, impotency, infertility and joint pains (Fahey 2005).

Bitter leaf (*V. amygdalina*) is a shrub or small tree of 2–5 m belonging to the family Asteraceae. It has petiolate leaves of about 6 mm diameter and elliptic shape. The leaves are green with a characteristic odour and a bitter taste (Singha 1996). In many parts of Nigeria, the plant has been domesticated (Igile *et al.* 1994). It is known as 'Ewuro' in Yoruba, 'Etidot' in Ibibio, 'Onugbu' in Igbo and 'Chusa-diki' in Hausa tribes in Nigeria (Egedigwe 2010). This plant grows under a range of ecological zones in Africa and produces large mass of forage and is drought tolerant; it is found in homes in villages as fence post and pot-herb (Bonsi *et al.* 1995). The result of the study shows that bitter leaf is a good source of protein, fibre and minerals, this support the findings of Ejoh *et al.* (2005) that it is an excellent source of vitamin C, total

carotenoid and minerals. These are used as vegetable in meals to stimulate the digestive system, and as a treatment for fever. A wide array of phytochemical has been shown to be present in *V. amygdalina*. The presence of oxalates, phytate and tannins have been reported (Ejoh *et al.* 2007; Eleyinmi *et al.* 2008), as well as flavonoids (Tona *et al.* 2004) were in accord with the present study. Bitter leaf extracts have been shown to exhibit profound ethno-medical and pharmacological properties such as anti-diabetic, anti-malarial, anti-helminthic and antibiotic properties (Farombi 2003).

Sweet potato (*I. batatas*) leaves are usually used to feed monogastric and ruminant animals under subsistence farming systems. Sweet potatoes contain a large amount of protein with a high amino acid score. The result of the study shows that sweet potato is a good source of protein, fibre and minerals and this support the report of Antia *et al.* (2006) who reported that leaves of the sweet potato are highly digestible, fairly rich in protein, a dietary source of vitamins, minerals, antioxidants, dietary fibre and essential fatty acid and free from toxin. Bioactive compounds contained in sweet potato leaves could contribute to health promotion and chronic disease prevention.

The result of this study revealed that some secondary metabolites are present in sweet potato leaves which agrees with the findings of Soetan and Oyewole (2009) who reported that this plants generally contain chemical compounds (such as saponins, tannins, oxalates, phytate, trypsin inhibitors, flavonoids and cyanogenic glycosides) known as secondary metabolites, and which are biologically active. Secondary metabolites may be applied in nutrition and as pharmacologically-active agents (Soetan and Oyewole 2009). They have antibacterial and anti-parasitic properties. Plants are also known to have high amounts of essential nutrients, vitamins, minerals, fatty acids and fibre (Gafar and Itodo 2011).

Flavonoids (quercetin) have inhibitory activity against disease - causing organisms in animals. Preliminary research indicates that flavonoids may modify allergens, viruses and carcinogens and so may be biological response modifiers. In vitro studies show that flavonoids also have anti allergic, anti – inflammatory, anti- microbial, anti – cancer and anti – diarrheal activities (Cushnie and Lamb 2011). Tannins are plant polyphenols, which have ability to form complexes with metal ions and with macro-molecules such as proteins and polysaccharides (Dei *et al.* 2007). Dietary tannins are said to reduce feed efficiency and weight gain in animal (Dei *et al.* 2007). Environmental factors and the method of preparation of samples may influence the concentration of tannins present. Tannin presence influences protein utilization and build defence mechanism against microorganism (Cushnie and Lamb 2011).

Saponins are glycosides, which include steroid saponins and triterpenoid saponins. High levels of saponins in feed affect feed intake and growth rate in animal (Dei *et al.* 2007). Saponins (in excess), causes hypocholestrolaemia because it binds cholesterol making it unavailable for absorption (Soetan and Oyewole 2009). Saponins also have haemolytic activity against red blood cell (Ogbe and Affiku 2011). Saponin-protein complex formation can reduce protein digestibility (Ogbe and Affiku 2011). Saponins reduced cholesterol by preventing its reabsorption after it has been excreted in the bile. Proper food processing would reduce anti-nutrients (Akinyeye *et al.* 2011).

Phytate is an organically bound form of phosphorus in plants. Phytate in foods are known to bind with essential minerals (such as calcium, iron, magnesium and zinc) in the digestive tract, resulting in mineral deficiencies (Bello *et al.* 2008). They bind minerals to form insoluble salts, thereby decreasing their bioavailability or absorption (Muhammad *et al.* 2011).

Oxalate binds with calcium to form calcium-oxalate crystals which are deposited as urinary calcium (stones) that are associated with blockage of renal tubules (Blood and Radostit 1989). Hydrogen cyanide is toxic when ingested by monogastric animals in large quantity. Soaking of plant materials or boiling in water is said to reduce toxic effects and improves utilization in terms of feed intake and protein digestibility (Dei *et al.* 2007).

5 | CONCLUSION

There is a need to explore and develop food and feed from alternate sources (e.g. non-conventional plant leaves); especially in view of rapidly growing population and the ever growing demands to improve agricultural system. Under these circumstances edible plant leaves may play a significant role.

Diet formulation with adequate ingredient is therefore the foundation on which animal nutrition is built. The nutritive values of studied locally available plant leaves tend to justify the continuous investigation and utilization of their potentials in animal feed. Possibly, the leaves from these plants could be useful as feed supplement and as medicine in animal nutrition to improve health and growth performance. Exploitation of these cheaper nutrient sources will lead to increased aquatic animal production. Further studies are recommended on inclusion of these leaves into the diets of aquatic animals at different inclusion levels to determine the optimum level for maximum production.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

REFERENCES

Adejinmi OO, Adejinmi JO and Adeleye IOA (2000) Replacement value of fish meal with soldier fly larvae meal in broiler diets. Nigerian Poultry Science Journal (1): 52–60.

Adejumo IO and Ologhobo AD (2012) Haematological response of broiler finishers fed differently processed taro cocoyam (*Colocasia esculenta* [(L.) Schott]. Agricultura Tropica Et Subtropica 45(3): 112–116.

Aderolu AZ, Lawal MO and Oladipupo MO (2009) Processed cocoyam tuber as carbohydrate source in the diet of juvenile African catfish (*Clarias gariepinus*). European Journal of Scientific Research 35(3): 453–460.

Adeyemi SAO (1987) Contribution of horticulture to food production in Nigeria by the 2000 AD. Acta Horticulture 211: 37–42.

Agbede JO, Ajaja K and Aletor VA (2002) Influence of Roxazyme G. supplementation on the utilization of sorghum dust-based diets for broiler-chicks. Proceedings of the 27th Annual Conference, Nigerian Society of Animal Production (NSAP), Akure 2002. pp. 105–108.

Agwunobi LN, Awukam PO, Cora OO and Isika MA (2002) Studies on the use of *Colocasia esculenta* (taro cocoyam) in the diets of weaned pigs. Tropical Animal Health and Production 34: 241–247.

Ajibade SR, Balogun MO, Afolabi OO and Kupolati MO (2006) Sex differences in the biochemical contacts of *Telfairia occidentalis* Hookf. Journal of Food, Agriculture and Environment 4: 155–156.

Akinyeye RO, Oluwadunsin A and Omoyeni A (2011) Proximate, mineral, anti-nutrients and phytochemical screening and amino acid composition of the leaves of *Pterocarpus mildbraedi* Harms. Electronic Journal of Environmental, Agricultural and Food Chemistry 10(1): 1848–1857.

Akoroda MO (1990) Seed production and breeding potential of fluted pumpkin. Euplthea 49(1): 25–32.

Aletor VA and Adeogun OA (1995) Nutrients and antinutrients components of some tropical leafy vegetables. Journal of Food Chemistry 54: 375–379.

Antia BS, Akpan EJ, Okon PA and Umoran IU (2006) Nutritive and anti- nutritive evaluation of sweet potatoes (*Ipomoea batatas*) leaves. Pakistan Journal of Nutrition 5: 166–168.

AOAC (2005) Official methods of analysis (Zeachtor WH, ed) 18th edition. Association of Official Analytical Chemist, Washington DC, USA. pp. 129–146.

Aravind G, Bhowmik D, Duraivel S and Harish G (2013) Traditional and medicinal uses of *Carica papaya*. Journal of Medicinal Plants Studies 1(1): 7–15.

Asadujjaman M and Hossain MA (2016) Fish growth, yield and economics of conventional feed and weed based polyculture in ponds. Journal of Fisheries 4(1): 353–360.

Babayemi OJ and Bankole MA (2009) Nutrient value and in vitro gas production of African wild cocoyam (*Colocasia esculentum*). African Journal of Food, Agriculture, Nutrition and Development 9(1): 593–607.

Bello MO, Farade OS, Adewusi SRA and Olawore NO (2008) Studies of some lesser known Nigerian fruits. African Journal of Biotechnology 7: 3972–3979.

Blood DC and Radostits OM (1989) Veterinary Medicine, 7th Edition. Balliere Tindall, London. pp. 589–630.

Bolaji PT, Komolafe GO and Alli E (2008) Drying characteristics of selected local vegetable. Nigerian Food Journal 26(1): 138–143.

Bonsi MLK, Osuji PO and Tuah AK (1995) Effect of supplementing teff straw with different levels of leucaena or sesbania leaves on the degradabilities of teff straw, sesbania, leucaena, tagasaste and vernonia and on certain rumen and blood metabolites in Ethiopian Menz sheep. Animal Feed Science and Technology 5: 101–129.

Cushnie TPT and Lamb AJ (2011) Recent advances in understanding the antimicrobial properties of flavonoids. International Journal of Antimicrobial Agents 38(2): 99–107.

Dei HK, Rose SP and Mackenzie AM (2007) Shea nut (*Vitellaria paradoxa*) meal as a feed ingredient for poultry. World's Poultry Science Journal 63(4): 611–624.

Disu SO (2010) "GBURE" the "water leaf" vegetable. http://digitalkobo09.blogspot.co.uk/2010/08/article-49-gbure-water-leaf-vegetable.html. Retrieved on 14 July 2014.

Djakalia B, Guichard BL and Soumaila D (2011) Effect of *Moringa oleifera* on growth performance and health status of young post-weaning rabbits. Research Journal of Poultry Science 4(1): 7–13.

Egedigwe CA (2010) Effect of dietary incorporation of *Vernonia amygdalina* and *Vernonia colorata* on blood lipid profile and relative organ weights in albino rats. MSc Dissertation, Department of Biochemistry, Michael Okpara University of Agriculture, Umudike, Nigeria. 148 pp.

Ejoh AR, Tanya AN, Djuikwo NA and Mbofung CM (2005) Effect of processing and preservation methods on vitamin C and total carotenoid levels of some *Vernonia* (bitter leaf) species. African Journal of Food, Agricul-

ture, Nutrition and Development 5: 105–117.

Ejoh RA, Nkonga DV, Innocent G and Moses C (2007) Nutritional components of some non-conventional leafy vegetables consumed in Cameroon. Pakistan Journal of Nutrition 6(6): 712–717.

Eleyinmi AF, Sporns P and Bressler DC (2008) Nutritional composition of *Gongronema latifolium* and *Vernonia amygdalina*. Nutrition and Food Sciences 38: 99–100.

Fahey JW (2005) *Moringa oleifera*: a review of the medical evidence for its nutritional therapeutic and prophylactic properties part 1. Tree for Life Journal 1: 5.

FAO (2001) Review of the state of world aquaculture. Food and Agriculture Organization, FAO fisheries circular No. 886, Rome, Italy.

Farombi EO (2003) African indigenous plants with chemotherapeutic potentials and biotechnological approach to the production of bioactive prophylactic agents. African Journal of Biotechnology 2(12): 662–671.

Fasuyi AO (2005a) Nutritional composition and processing effects on cassava leaf (*Manihot esculanta* Crantz) anti nutrients. Pakistan Journal of Nutrition 4: 37–42.

Fasuyi AO (2005b) Nutritional potentials of some tropical leafy vegetables meals: chemical characterization and functional properties of fresh and frozen vegetables. Food Chemistry 62(1): 59–64.

Fasuyi AO (2006) Nutritional potential of some tropical vegetable meals. Chemical characterization and functional properties. African Journal of Biotechnology 5(1): 49–53.

Fasuyi AO and Nonyerem AD (2007) Biochemical, nutritional and haematological implications of *Telfairia occidentalis* leaf meal as protein supplement in broiler starter diets. African Journal of Biotechnology 6(8): 1055–1063.

Ferreira PMP, Farias DF, de Olivera JTA and de Carvalho AFU (2008) *Moringa oleifera*: bioactive compounds and nutritional potential. Revista de Nutrição 21(4): 431–437.

Gafar MK and Itodo AU (2011) Proximate and mineral composition of hairy indigo leaves. Electronic Journal of Environmental, Agricultural and Food Chemistry 10(3): 2007–2018.

Galib SM, Hoque MN, Akter S, Chaki N and Mohsin ABM (2016) Livelihood, climate change and fisheries: a case study of three fishing communities of northwestern Bangladesh. International Research Journal of Social Sciences 5(8): 18–25.

Galib SM, Mohsin ABM, Chaki N, Fahad MFH, Haque SMM (2013) An overview of the traditional rice-prawn-fish farming in Kalia of Narail district, Bangladesh. Journal of Fisheries 1(1): 1–6.

Grubben GJH and van Sloten DH (1981) Genetic Resources of Amaranths, International Board for Plant Genetic Resources, Food and Agriculture Organisation, Rome 20 pp.

Hidajat A and Wargiono J (2002) Contribution of cassava leaves used as a vegetable to improved human nutrition in Indonesia. VII Asian Cassava Research IND Technical Information Services (TIS)/ KMUTT.

Hossain MA, Mohsin ABM, Galib SM, Alam R and Samad AOMA (2009) Potentials of khas (public) ponds and kharis (canals) in Barind tracts: sustainable rural livelihoods in the face of climate change. Bangladesh Journal of Progressive Science & Technology 7(1): 49–52.

Idris S (2011) Compositional studies of *Telfairia occidentalis* leaves. American Journal of Chemistry 1 (2): 56–59.

Igile GO, Olezek W, Jurzysata M, Burda S, Fafunso M and Fasanmade AA (1994) Flavonoids from *Vernonia amygdalina* and their antioxidant activities. Journal of Agricultural and Food Chemistry 42(11): 2445–2448.

Islam MR, Hoque MN, Galib SM and Rahman MA (2013) Livelihood of the fishermen in Monirampur Upazila of Jessore district, Bangladesh. Journal of Fisheries 1(1): 37–41. doi: 10.17017/jfish.v1i1.2013.8

Kamal MM, Mondol RK, Galib SM and Nahar MDG (2010) A study on traditional prawn farming systems at Manirampur Upazila of Jessore, south-west district of Bangladesh. Journal of Environmental Science & Natural Resources 3(1): 143–146.

Kayode AA and Kayode OT (2011) Some medical values of *Telfairia occidentalis*: a review. American Journal of Biochemistry and Molecular Biology 1: 30–38.

Kola F (2004) Proximate composition of bungu leaves and seeds. Biochemistry 16: 1–8.

Makkar HPS and Becker K (1997) Nutrient and anti quality factors in different morphological part of *Moringa oleifera* tree. Journal of Agricultural Sciences 128: 311–322.

Mepba HD, Eboh L, Banigo DEB (2007) Effects of processing treatments on the nutritive composition and consumer acceptance of some Nigerian edible leafy vegetables. African Journal of Food, Agriculture, Nutrition and Development 7(1): 1–18.

Merck O (2005) Mineral deficiencies. The Merck Veterinary Manual, Ninth Edition. Published by Merck and Co. Inc., Whitehouse Station, New Jersey, USA. pp. 2320–2330.

Mohsin ABM, Islam MN, Hossain MA and Galib SM (2012a) Cost-benefit analyses of carp polyculture in ponds: a survey study in Rajshahi and Natore districts of Bangladesh. Bangladesh Journal of Environmental Science 23: 103–107.

Mohsin ABM, Islam MN, Hossain MA and Galib SM (2012b) Constraints and prospects of carp production in

Rajshahi and Natore districts, Bangladesh. University Journal of Zoology, Rajshahi University 31: 69–72.

Muhammad A, Dangoggo SM, Tsafe AI, Itodo AU and Atiku FA (2011) Proximate, minerals and anti-nutritional factors of Gardenia aqualla (*Gauden dutse*) fruit pulp. Pakistan Journal of Nutrition 10(6): 577–581.

Ndabikunze BK, Talwana HAL, Mongi RJ, Isa-Zacharia A, Serem AK, Palapala V and Nandi JOM (2011) Proximate and mineral composition of cocoyam (*Colocasia esculenta* L. and *Xanthosoma sagittifolium* L.) grown along the Lake Victoria Basin in Tanzania and Uganda. African Journal of Food Science 5(4): 248–254.

Nwanna LC and Olusola SE (2014) Effect of supplemental phytase on phosphorus digestibility and mineral composition in Nile tilapia (*Oreochromis niloticus*). International Journal of Aquaculture 4(15): 89–95. doi: 10.5376/ija.2014.04.0015

Ogbe O and Affiku JP (2011) Proximate study, mineral and anti-nutrient composition of *Moringa oleifera* leaves harvested from Lafia, Nigeria: potential benefits in poultry nutrition and health. Journal of Microbiology, Biotechnology and Food Sciences 1(3): 296–308.

Ogunlakin GO, Oke MO, Babarinde GO and Olatunbosun DG (2012) Effect of drying methods on proximate composition and physic-chemical properties of cocoyam flour. American Journal of Food Technology 7(4): 245–250.

Oguntona T (1998) Green leafy vegetables. In: Osagie AU and Eka OU (Eds) Quality of Plant Foods. Post Harvest Research Unit, University of Benin, Benin City. pp. 120–130.

Oke OL (1983) Amaranth. In: Chan HT Jr (ed) Handbook of tropical foods, Marcel-Dekker Inc., New York, USA. 189 pp.

Okoli EC, Nworka OO and Unaogbu T (1998) Blanching and storage of some Nigerian vegetables. International Journal of Food Science 23: 639–641.

Okon B, Ibon LA, Nsa EE and Ubua JA (2012) Reproductive and growth traits of parents and F1 hatchings of *Achatina achatina* (L.) snails under mixed feeding regime with graded levels of swamp taro cocoyam (*Cyrtosperma chamissonis*) and pawpaw leaves (*Carica papaya*). Journal of Agricultural Science 4(11): 289–298.

Olajide R, Akinsoyinu AO, Babayemi, OJ, Omojola AB, Abu AO and Afolabi KD (2011) Effect of processing on energy values, nutrient and anti-nutrient components of wild cocoyam (*Colocasia esculenta* (L.) Schott) corm. Pakistan Journal of Nutrition 10(1): 29–34.

Oluwalana IB, Ayo JA, Idowu MA and Malomo SA (2011) Effect of drying methods on the physicochemical properties of water leaf (*Talinum triangulare*). International Journal of Biology and Chemistry Science 5(3): 880–889.

Oluyemi EA, Akilua AA, Adenuya AA and Adebayo MB (2006) Mineral contents of some commonly consumed Nigerian foods. Science Focus 11: 153–157.

Opute FI (1979) Seed lipids of the grain amaranths. Journal of Experimental Botany 30: 601–609.

Osuagwe GG (2008) Proximate and vitamin content of four Nigerian *Pterocarpus* species. Nigerian Food Journal 26(1): 21–26.

Oyenuga VA (1968) Nigerian foods and feeding stuffs, their chemistry and nutritive value. Ibadan University Press, Ibadan. 99 pp.

Oyenuga VA and Fetuga BL (1975) First national seminar on fruits and vegetables, In: Process and Recombination by NIHORT, Ibadan, Nigeria. pp. 13–17.

Sanchez-Machado DI, Nunez- Gatelum JA, Reyes-Moreno C, Ramirez-Wong B and Lopez–Cervantes J (2010) Nutritional quality of edible part of *Moringa oleifera*. Food Analytical and Methods 3: 175–180.

Shakuntala MN and Shadaksharaswamy M (1985) Foods (Facts and Principles). Wiley Eastern Limited: New Delhi, India. 301 pp.

Singha SC (1996) Medicinal plants in Nigeria. National Press Limited, Apapa. 49 pp..

Soetan KO and Oyewole OE (2009) The need for adequate processing to reduce the anti-nutritional factors in animal feeds: a review. African Journal of Food Science 3(9): 223–232.

Sukamoto LA (2003) Development of early maturing and leaf blight resistant cocoyam (*Colocasia esculenta* (L.) Schott) with improved taste. Proceedings of final research coordinated meeting organized by the joint FAO/IAEA division of nuclear technique in food agriculture held in Pretoria, South Africa. pp. 19–23.

Tona L, Cimanga RK, Mesia K, Musuamba CT, Bruyne T, Apers S, Hermans N, Van Miret S, Pieters L, Totte J and Vlietnk AJ (2004) In vitro antiplasmodial activity of extracts and fractions of seven medicinal plants used in Democratic Republic of Congo. Journal of Ethnopharmacology 93: 27–32.

Tuleun CD, Patrick JP and Tiamiyu LO (2009) Evaluation of raw and boiled velvet bean (*Mucuna utilis*) as feed ingredient for broiler chickens. Pakistan Journal of Nutrition 8(5): 601–606.

Ugwu CE, Olajide JE, Alumana EO and Ezeanyika LUS (2011) Comparative effects of the leaves of *Vernonia amygdalina* and *Telfairia occidentalis* incorporated diets on the lipid profile of rats. African Journal of Biochemistry Research 5(1): 28–32.

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