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Nutrient content of young cassava leaves and assessment of their acceptance as a green vegetable in Nigeria

A.F. AWOYINKA,[1] V.O. ABEGUNDE[1] & S.R.A. ADEWUSI[2]*

[1]*Home Economics Programme, Department of Agricultural Extension, and* [2]*Department of Chemistry, Obafemi Awolowo University, Ile-Ife, Nigeria* (**author for correspondence*)

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Abstract. Cassava (*Manihot esculenta* Crantz) leaves contained a high level of crude protein (29.3–32.4% dry weight) compared to a conventional vegetable, *Amaranthus* (19.6%). Ash was 4.6–6.4% in cassava leaf samples but 13.1% dry weight in *Amaranthus*. Dietary fibre was very high in all samples (26.9–39% dry weight) while HCN-potential was low (5.1–12.6 mg/100 g dry weight). Tannin was the highest in IITA red cassava leaves (29.7 mg/g) and the lowest in *Amaranthus* vegetable. In vitro digestibility was very low in oven dried samples (15.6–22.7%). Blanching increased protein content (except *Amaranthus*) and in vitro protein digestibility but decreased ash, minerals, dietary fibre and tannin, while HCN-potential was unchanged. Grinding reduced both HCN-potential and tannin by 84 and 71% respectively while oven drying only reduced the HCN content marginally. Preference studies showed that the highest percentage of respondents (25.3%) preferred *Amaranthus* vegetable, followed by Celosia (17.5%), Talinum (12.4%), garden egg (11.5%), with cassava leaves as the least (0.5%). Organoleptic evaluation rated cassava leaf soup inferior to *Amaranthus* in terms of appearance, colour and texture but equal in terms of taste and flavour and overall acceptability.

Introduction

Oke [1] advocated the use of vegetables to combat protein malnutrition in the developing countries and dark green vegetables have now been recognised as one of the richest natural sources of vitamin A. The cost of animal proteins has increased at least ten fold over the last fifteen years while structural adjustment progammes of many developing countries have lowered the standard of living as well as the nutritional status of the people with its attendant diseases especially kwarshiokwor in children. Green vegetables like *Amaranthus*, *Celosia* and *Vernonia* serve as a protein source for millions of people in the tropics but these are now becoming expensive. It is therefore high time other sources of green vegetables are investigated and exploited.

Cassava is one of the most versatile crops now cultivated in Africa, mostly for its tuber which is a rich source of calories and industrial starch. Though young cassava leaves contain a high (40%) protein content, vitamins A, B, C, and E and minerals like iron, calcium and phosphorus [2–4]; they also have a

few antinutritional factors such as the cyanogenic glucosides – linamarin and lotaustralin – which on hydrolysis yield HCN. HCN at levels of 50 mg and above can be lethal to a 70 kg man [5] while sublethal doses can cause tropical ataxic neuropathy, optic amblyopia, goiter and cretinism in children [5–7]. The poor digestibility and utilization of cassava leaf protein have also been linked to the presence of condensed tannins in these leaves [8, 9].

The purpose of the present investigation therefore was: (1) to carry out the proximate analysis of the young leaves of three widely cultivated varieties of cassava in Nigeria; (2) to evaluate the acceptability of cassava leaf as a green vegetable in soups and stews; (3) to determine the level of toxic/antinutritional constituents; and (4) to propose methods of detoxification.

Experiment

Young leaves of three varieties of cassava, viz: 'oko iyawo', (local sweet variety), IITA white (TMS 30555), IITA red (TMS 30572) and white *Amaranthus* species were harvested from the Teaching and Research Farm of this university between May and September, 1988 and 1989 respectively. Part of the samples were cleaned of dirt and foreign matter and dried at 70 °C for 3 days in an air oven and milled to serve as the control for processing purposes. Two other processing methods compared with this control were (a) the four vegetables were blanched at 100 °C for 5 min, and (b) leaves of IITA red were cut into pieces, ground and left for 2 hours at room temperature.

Methods. Moisture and nitrogen (N) content were determined by the standard AOAC method [10] and crude protein obtained by multiplying the N by 6.25 and lipid was extracted using 2:1 (v/v) chloroform-methanol. Ash content was evaluated by heating the samples in a muffle furnace at 650 °C for 4 hours. Iron and calcium content were determined by the atomic absorption spectrophotometer and phosphorus by the molybdenum blue colorimetric technique. Dietary fibre was estimated using the Sigma total dietary fibre kit. Tannin content was determined by the modified vanillin-HCl method [11]. Screening for HCN was carried out according to the method of Feigl & Anger [12] and quantitatively determined by the modified Konig reaction [13] after enzymic (endogenous and/or exogenous) hydrolysis of the cyanoglucosides followed by steam distillation into sodium hydrogen carbonate solution or trapping the HCN in 0.1 M NaOH in center well flasks. In vitro protein digestibility was estimated by the method of Singh & Jambunathan [14] except that nitrogen in the residue was determined.

Preference studies. A total of 217 randomly selected people from the workers of the university were asked to choose the vegetable, they most commonly consumed from a list of 17 vegetables available in Nigeria.

Acceptability evaluation. Vegetable soup* was prepared using the recipe of Anthonio & Isoun [15] with IITA white young cassava leaves which contained the lowest cyanogenic glucoside but comparatively high level of protein, iron, calcium and phosphorus. *Amaranthus* was used as the control. The leaves were blanched at 100 °C for 5 min and added to the ingredients already fried in palm-oil for 10 min. The soup was then allowed to steam for 5 min and mixed thoroughly. The two soups were served to an untrained panel of 75 people of mixed sex, age, profession and educational background as a blind test to evaluate the appearance, colour, texture and flavour. This large number of taste panelists was chosen from the wide spectrum of the federal university workers to represent the different ethnic groups of Nigeria as much as possible and for reliable statistical analysis.

Data analysis. The results of chemical analysis were presented as the mean of three determinations. The organoleptic evaluation of the two soups was subjected to an unpaired two-sample t-test according to Larsen & Marx [16].

Results and discussion

Moisture content was higher in fresh Amaranthus ($86.7 \pm 1.2\%$), than in the leaves of the three cassava cultivars (Table 1) indicating that Amaranthus leaves may be more succulent but also more susceptible to deterioration during storage than cassava leaves. There was only a narrow variation in the protein content of the young leaves of the three cassava varieties with the highest content in IITA white (32.4%) followed by oko iyawo (31.3), IITA red (29.3%) and the least in Amaranthus leaves (19.6% dry weight; mean cv 5.3%). Mature cassava leaves have been reported to contain 22% protein while young leaves contained up to 39.9% protein dry weight [4]. Compared to Amaranthus leaves and other Nigerian vegetables [17]; young cassava leaves contained the highest CP and if utilizable, it should be an asset in human nutrition.

Lipid content was generally low (1.6–1.8% dry weight) supporting the earlier observations of 1.0–1.3% fat content [18]. Ash content was the lowest (4.6%) in oko iyawo variety, 6.0 and 6.4% for IITA white and red varieties respectively while it was very high (13.1%) in Amaranthus leaves. The percentage ash value for cassava leaves had been estimated at about 2% [18] but this is expected to vary with leaf age and environmental factors. Indeed, ash content between 6.2–19.4% had earlier been recorded for four Nigerian vegetables [17]. Iron is important in the diet of both pregnant and nursing mothers as well as infants, the convalescent and the elderly to prevent anaemia. Iron content was highest in Amaranthus leaves (800 mg/kg dry weight) and lowest in IITA red cassava

* Soup recipe: 600 g vegetable (cassava or amaranthus leaves); 12 g fresh pepper; 270 g fresh tomato; 150 g onion; 10 g fermented locus bean and 90 mL cooking oil. Crayfish which could mask the taste and flavour of the vegetable soup was omitted.

Table 1. Moisture, crude protein, lipid, ash, mineral, dietary fibre, HCN-potential, tannin and in vitro digestibility of fresh, oven-dried and blanched cassava and amaranthus leaves

Analysis	Oko iyawo			IITA white			IITA red			Amaranthus			
	Fresh	Oven-dried	Blanched	Fresh	Oven-dried	Blanched	Fresh	Oven-dried	Blanched	Ground	Fresh	Oven-dried	Blanched
Moisture (%)	78.4	—	—	80.6	—	—	78.0	—	—	—	86.7	—	—
Crude protein (%)	—	31.3	32.9	—	32.4	36.1	—	29.3	35.7	—	—	19.6	18.7
Lipid (%)	—	1.8	—	—	1.7	—	—	1.8	—	—	—	1.6	—
Ash (%)	—	4.6	2.9	—	6.0	3.0	—	6.4	5.1	—	—	13.1	8.4
Iron (mg/kg)		270	201		235	134		218	168			800	235
Calcium (mg/kg)		429	815	—	500	901	—	551	1,216	—	—	3,575	458
Phosphorus (mg/kg)	—	780	780	—	710	710	—	800	860	—		810	840
Dietary fiber (%)	—	26.9	25.0	—	33.7	32.0	—	35.5	33.1	—	—	39.0	36.2
HCN-potential (mg/100 g DW)	12.6	10.5	12.7	8.1	10.5	8.0	12.6	10.5	12.4	2.0	5.1	5.1	0
Tannin (mg/g)	–	2.1	1.6	—	8.3	1.5	—	29.7	2.2	8.7	—	0.6	0.6
In vitro digestibility %	—	20.5	68.0	—	15.6	61.2	—	19.2	58.6	—	—	22.7	77.3

leaves (218 mg/kg). This mineral is high in cassava leaves when compared to other plant food sources [18] but in the lowest range when compared to other Nigerian vegetables [17]. Calcium was also very high in Amaranthus leaves (3,575 mg/kg dry weight); significantly higher than in cassava leaves (429–551 mg/kg). Fresh Amaranthus leaves could therefore be considered as a rich source of calcium. Phosphorus was relatively constant in all the samples investigated ranging from 710 mg/kg for IITA white cassava leaves to 810 mg/kg dry weight for Amaranthus leaves.

Dietary fibre was very high in all the samples – 26.9% in 'oko iyawo' and 39% dry weight in Amaranthus. High fibre content has been adduced as one of the major constraints in the use of vegetable leaves in human nutrition [1] and the result of this investigation has confirmed it. HCN-potential in fresh cassava leaves was 8.1–12.6 mg HCN/100 g fresh weight. Higher values from 8.3 to 101.6 mg/100 g fresh weight have been reported [19, 20]. The low HCN-potential reported in this investigation would probably be due to the tender leaf age of these 'low cyanide' varieties of cassava. The authors were surprised by the high cyanide content obtained for Amaranthus leaves but screening for cyanide by the Feigl-Anger method [12] gave a negative result. This tends to show that Amaranthus leaves probably contained a volatile compound that could react in the Lambert et al. assay [13]. Such compounds like benzoyl thiocyanate have been known to exist in some plants [5].

Tannin content was negligible in Amaranthus leaves (0.6 mg); low in 'oko iyawo' variety (2.1 mg/100 g) but high – 8.3 and 29.7 mg/100 g in IITA white and red cassava varieties respectively. As pointed out earlier, tannin inhibits protein digestion and absorption (8) and unless it can be reduced substantially, tannin could affect the protein utilization of both white and red IITA cassava leaves.

In vitro digestibility of oven-dried cassava leaves was very low (15.6–20.5%). In addition to the high tannin content, cassava leaves contain an appreciable amount of dietary fibre and protease inhibitors [21]. It is therefore apparent that oven drying at 50–70 °C did not improve digestibility hence alternative methods have to be developed if cassava leaves would be promoted for consumption.

Effect of processing. Blanching at 100 °C for 5 min, which is the commonest method of processing vegetables in Nigeria, increased protein content of cassava leaves by between 5.1% in 'oko iyawo' and 21.8% in IITA red cassava leaves. Protein content of Amaranthus slightly decreased due to blanching as a result of leaching during the process. Ash content was generally reduced by 20.3–50% by blanching again showing that hot water could effectively leach minerals as shown by the 22.9–86.2% decrease in iron and the monovalent ions (Table 1). Blanching increased calcium content by 80–120.7% in cassava leaves but reduced that of Amaranthus leaves by 87.2%. This showed that calcium in cassava leaves may be in a bound form such as calcium oxalate and not easily leached whereas calcium in Amaranthus could exist in the ionic form or

complexed to a ligand that can be easily leached by hot water. No appreciable change in phosphorus content occurred with blanching, while dietary fibre was decreased marginally.

Essers [22] observed that boiling cassava leaves in water reduced its cyanide toxicity but Bradbury (pers. comm.) has suggested that maintaining the temperature at 60–65 °C, the optimum range for plant enzymes' activity could be expected to reduce the cyanide potential further. Blanching, however, did not affect the HCN-potential of cassava leaves presumably due to the fact that the leaves were introduced into the boiling water which would destroy linamarase – the hydrolytic enzyme – without affecting the cyanoglucosides. Ingestion of blanched cassava leaves could therefore lead to the hydrolysis of the bound HCN by the intestinal microflora [23, 24] or exogenous enzymes taken orally in fruits and vegetable products. Fortunately, the HCN potential of the leaves was low and, in the absence of exogenous enzymes, no danger could be envisaged.

Blanching reduced the tannin content by 23.8% in 'oko iyawo', 82 and 93% in IITA white and red cassava leaves respectively. Blanching for 5 minutes turned the water brownish showing that leaching of coloured materials had occurred though tannin-protein and/or tannin-tannin polymerization cannot be ruled out [25]. Blanching also improved the digestibility by reducing the tannin content and through the inactivation of the protease inhibitors. Pounding cassava leaves, or chopping them finely, leaving it to ferment for a day or two and/or boiling for several hours is a traditional process used by all the peoples where cassava leaf is consumed [3]. Grinding cassava leaves and leaving it for just 2 hours at room temperature reduced the HCN-potential of IITA red cassava leaves by 84% and tannin by 71%. The reduction was probably due to the increased enzyme-substrate contact effected by maceration.

Organoleptic evaluation of cassava leaf vegetable soup. The result presented in Table 2 showed that 55 people or 25.3% of those interviewed claimed to eat Amaranthus regularly while only 1 or 0.5% claimed to have eaten cassava leaves before the survey. This shows that the cassava leaf is not yet popular as a vegetable among the predominantly Yoruba ethnic group surveyed. As a vegetable soup, Amaranthus was preferred to cassava leaf in appearance as revealed by the data in Table 3. This was further confirmed by the panel scoring the colour of Amaranthus as being superior to that of the cassava leaf soup. The green colour is an aesthetic quality highly valued in vegetables and the lighter the better which seemed to form the basis for the panels' preference. Though the panel described the texture of both soups as being the same statistically, Amaranthus leaf soup was graded significantly better when tasted. This preference is in conformity with the higher moisture content of Amaranthus leaves probably making it more succulent. There was however no significant difference in the taste and flavour as well as the overall assessment of both soups. The panels' preference was 38.7% for cassava leaves, 34.7% for

Table 2. Frequency distribution and percentage of the Higerian vegetables as preferred by the 217 respondents

Botanical name	Common/Local name	Frequency	Percentage
Amaranthus viridis L.	Green/Tete[a]	55	23.3
Celosia trigyna L.	Soko[a]	38	17.5
Talinum triangulare L.	Water leaf/Gbure[a]	27	12.4
Solanum incanum L.	Garden egg	25	11.5
Vernonia amygdalina Del.	Bitter leaf/ewuro[a]	15	6.9
Corchorus estuans L.	Gute mallow/ewedu[a]	11	5.1
Gynura cernea L.	Ebolo[a]	10	4.6
Crassocephalum biafrao (Oliv. & Hiern.)	Worowo[a]	7	3.2
Solanum nigrum L.	Odu[a]	7	3.2
Hibiscus esculentus L.	Okra/Ila[a]	5	2.3
Bassella alba L.	Indian spinach	5	2.3
Telfairia occidentalis Hook F.	Ugwu[b]	4	1.8
Cucurbita pepo L.	Pumpkin	2	0.9
Gnetum africanum Welw.	Okazi[b]	2	0.9
Pterocarpus milbraedi L.	Oha[b]	2	0.9
Chlorophora excelsea L.	Ila iroko[a]	1	0.5
Manihot esculentus Crantz.	Cassava	1	0.5

[a] Nanmes of vegetables in Yoruba.
[b] Names of vegetables in Igbo.

Table 3. Sensory evaluation of cassava leaf and amaranthus vegetable soup

Characteristics	Vegetable soup		
	Cassava	Amaranthus	t_{cal}
Appearance	3.44[b]	4.72[a]	9.02
Colour	3.52[b]	4.76[a]	3.02
Texture[z]	4.17[a]	4.36[a]	1.04
Texture[y]	4.20[b]	4.55[a]	2.05
Taste and flavour	4.67[a]	4.40[a]	1.50
Overall assessment[x]	4.31[a]	4.12[a]	1.34

t_{148} (0.05) = 1.96
Values with the same letters are not significantly different at $p \leqslant 0.05$.
[z] Texture was graded by touch only.
[y] Texture was graded by tasting the soups.
[x] The panels' overall preference was 38.7% for cassava leaf, 34.7% for amaranthus, 25.3% for both vegetables while 1.3% preferred neither.

Amaranthus while 25.3% liked both soups equally and only 1.3% did not like either (Table 3).

Overall, cassava leaf seems to be acceptable as a green vegetable in traditional Nigerian diets and could be encouraged for consumption provided that the proper processing methods (such as grinding, chopping the leaves finely and/or heating at 60 °C for about 15–30 minutes) to reduce the cyanide and tannin content of the leaves are introduced.

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