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Cultivation, Food Values and Adoption of Technologies for Sustainable Production of *Gnetum africanum*

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Abstract: A study on the cultivation, food values and farmers' perception on the adoption of recommended technologies on *Gnetum africanum* was conducted in the southeastern zone of Nigeria. The study was done in three segments: (i)land preparation and random collection of soil samples with a soil auger from depths of 0-10cm and 10-20 cm of each block for analysis to establish the soil nutrient levels and for the cultivation of *G. africanum* seedlings in a randomized complete block design, replicated three times; (ii) harvesting of *G. africanum* leaves randomly at maturity from the plots for determination of proximate composition (mg/100g), for mineral content (mg/100g) and for vitamin C content of raw, sun-dried, blanched and boiled samples; and (iii) use of a participatory rapid appraisal (PRA) and sample survey to collect data by interviewing 65 farmers on adoption of *G. africanum* recommended technologies. Data collected were subjected to analysis of variance (ANOVA) and the least significant difference (LSD) used in separating the means w here differences occurred at the 5% level. In the third segment, Matrix ranking was used for evaluating farmer preferences to agroforestry and traditional system. The Likert scale, the Levy's approach and the Probit Maximum Likelihood Analysis were used to estimate the relationship of specific determinants in adoption of *G. africanum* technologies. The results of the study reveal that the number of leaves, vines and the height of *G. africanum* was increased with increasing number of months after planting (MAP). The results also shows that crude protein and carbohydrate were increased in leaves of *G. africanum.* The minerals and vitamin C contents of *G. africanum* in the various samples were high. The probit coefficients show that all the endogenous variables except sex had a negative effect on the adoption process. Income of the farmers positively and significantly influenced adoption.Women predominantly cultivated *G. africanum*, which is influenced by the size of land required. Consistent training on cultivation and processing of *G. africanum* leaves for home dishes and income should be conducted for women so as to obtain the maximum food values and increase sustainability in production.

Key words: Cultivation % Food % Adoption % *G. africanum*

INTRODUCTION

Gnetum africanum is an African vegetable grown mainly for its leaves. It belongs to the family, Gnetaceae and Order, Gnetales*. Gnetum* can be classified as a climber because it produces vines, which can wind round a stake in a clockwise direction*. G.africanum* is an African indigenous crop mainly collected for its leaves. This indigenous leafy vegetable has contributed significantly to the nutritional well-being of communities as suggested by Chweya and Eyzaguirre [1].

Initially, *G. africanum* grew and was harvested in the wild, but due to the high rate of deforestation and bush burning, it was recommended in 1995 by the Akwa Ibom State Agricultural Development Programme (AKADEP) to farmers in the southeastern zone of Nigeria for cultivation in the homestead gardens to avoid extinction and for generation of income. However, Olasantan [2] and Isong *et al* [3] maintain that *G. africanum* still grows and is harvested from the wild. *Gnetum* has several names as there are several ethnic groups that consume it in Nigeria and in Cameroon. In Nigeria, the Ibibios and Efiks call

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G. africanum "Afang", in Ikom of Cross River State, it is called "Nkani ", in Igbo it is called "Ogazi" and in the Anglophone Cameroon, it is called "Eru" and in the Francophone Cameroon, it is known as "Okok". *G. africanum* requires a large quantity of biomass and sunlight for its photosynthetic process and that is why it sprouts in full capacity on trees and shrubs (live stakes) during the dry season. Leaves of *G. africanum* are consumed by most households in Akwa Ibom State of Nigeria. Since the crop has been introduced to farmers for homestead cultivation, live stakes, viz: *Leucana leucocephala, Gliricidia sepium*, which are introduced and fast growing trees and a local plant, *Anthonata macrophylla* were also introduced in the study.

The study was conducted in 2006, about 14 years after the improved practices in *G. africanum* were introduced to the farmers by the Agricultural Extension Agency. Currently, low emphasis is placed on the use of inorganic fertilizers, but high emphasis on generation of income in the rural economy, reduction in extinction of indigenous useful plant species and afforestation. Therefore, no inorganic fertilizers were applied but clippings from the agroforestry trees were applied as organic matter to the soil. No irrigation was used. The crop was raised under natural conditions and under rainfed conditions. Because the crop is becoming a predominant vegetable crop for women in the area of study for food and income, it became necessary to cultivate *G. africanum*, establish its growth parameters, its food values and examine the status of adoption of the recommended technologies for growing the crop by the farmers.

MATERIALS AND METHODS

The Study Was Conducted in Three Segments: (i) land preparation, cultivation and harvesting of *G. africanum at* maturity; (ii) the *G. africanum* leaves are consumed in raw, sun-dried, blanched and boiled forms at the various stages in the crop by the people of the southeastern states in Nigeria; therefore it became necessary to determine the food values of *G. africanum*; and (iii) interview farmers on adoption of *G. africanum* on the improved practices. The study was conducted in the Faculty of Agriculture, University of Uyo. The area lies within the tropical rainforest zone of Nigeria of Latitude 5.00°N and Longitude 7.00°E. The rainfall ranges from 1800-3200 mm per annum. The annual temperature varies between 22.85°C and 30.13°C; the mean relative humidity is 76.25% and with the monthly sunshine of 8.31 hours [4]. Working of the soil was done manually with simple farm tools such as machete and spade. Soil samples were randomly collected with a soil auger from depths of 0-10 cm and 10-20 cm in each block for analysis to establish the level of soil nutrients.

The experimental area measured 20 m x 15 m or 300 m^2, equivalent to 0.03 hectare. *Leucaena leucocephala* and *Gliricidia sepium* were planted at 4 m x 0.25 m, respectively in the plots while *G. africanum* was planted at 1 m x 1 m replicated three times in a randomized complete block design. The mean height for *L. leucocephela*, *G. sepium* and *G. africanum* at seedlings at planting were 30 cm, 30 cm and 20 cm respectively. They were all planted in March 1998.

Data were collected from the plots with a measuring tape for the heights of *G. africanum*, *L. leucocephala*, *G. sepium* and *A.macrophylla.* Number of leaves and vines of *G. africanum* were counted at 4 months interval and recorded. Data were subjected to analysis of variance (ANOVA) and the least significant difference (LSD) used to separate the means where differences occurred at 5% level.

The *G. africanum* leaves were randomly harvested from the plots in 2006 for the determination of proximate composition (mg/100g), for mineral content (mg/100g) and for vitamin C content [5] at raw, sun-dried, blanched and boiled stages of the samples by adopting the AOAC [5] method. The samples were blanched in hot water at 70°C for 10 minutes, boiled at 100°C for 5 minutes and sundried for 8 hours for three respective days at 25-28°C.

Finally, a list of *G. africanum* farmers in Uyo zone of AKADEP was constructed and 65 AKADEP farmers were randomly selected from the list to take part in the study. A Participatory Rapid Appraisal (PRA) and sample survey were used to collect data from the AKADEP farmers. Both matrix ranking and focus group discussion (FGD) were used in the PRA. Variables in determining adoption of recommended technologies for *G. africanum* cultivation included socioeconomic characteristics: (i) Endogenous-Gender, age, level of education and farming experience. (ii) Exogenous - Status of land tenure, number of farm plots, sources of labour, access to credit, access to extension service, off farm jobs, annual income and membership in cooperative organizations. In adoption, consideration is given to the behaviour of individuals with regards to technology. And more particularly, reasons of adoption at a point in time are of significant concern. Therefore, three analytical instruments were employed in the study. The instruments are the Likert scale, the Levy's approach [6] and the Probit Maximum Likelihood Analysis [7].

RESULTS

Table 1 shows the number of leaves of *G. africanum* at 4 months through 32 months after planting (MAP). At 4 MAP, there was no significant difference in the number of leaves of *G. africanum* on the live stakes: *L. leucocephala, G. sepium.* and *A .macrophylla* From 8 MAP, there was a gradual increase in the number of leaves of *G. africanum* and increased significantly from 20 to 32 MAP. This indicated a significant improvement in the growth pattern of the crop. Table 2 shows also the heights of *G. africanum* from 4 MAP through 32 MAP. There was no significant difference on the height of *G. africanum* at 4 MAP. However, a gradual increase in the height of *G. africanum* was obtained from 8 to 32 MAP. Finally, Table 3 shows the number of vines of *G. africanum* from 4 to 32 MAP. Generally, there was a gradual but steady increase in the number of vines from 4 to 32 MAP. The *L. leucocephala, G. sepium.* and *A.macrophylla* were used as live stakes and clippings used as organic matter.

Proximate Composition: Table 4 shows the proximate composition of *G. africanum* in raw, sun-dried, blanched and in the boiled form. The boiled sample had the highest moisture content of 87.3 and 86.4% in raw, 85.7% in blanched and 82.2% in the sun-dried. Crude protein in the sample was 6.1% in the sun-dried material, 5.2, 5.0 and 4.4% in raw, blanched and in boiled samples, respectively. Lipid was 1.3% highest for sun-dried sample and 0.7, 0.6 and 0.4% for raw, blanched and boiled samples, respectively. Carbohydrate in the samples ranged from 3.0, 3.2, 3.6 to 4.3% in boiled, blanched, raw and in sun-dried samples, respectively. For crude fibre, sun-dried sample was 2.7% followed by 2.5% for blanched, 2.1% for boiled and 1.8% for the raw sample of *G. africanum* leaves. Finally, 3.4, 3.1, 2.8 and 2.3% in that order represented the composition of ash in sun-dried, blanched, boiled and raw samples.

Table 1: Number of leaves of *Gnetum africanum* growing on leguminous tree species

Trees	4MAP	8MAP	12 MAP	16MAP	20MAP	24MAP	28MAP	32MAP
Leucaena	11	14	19	21	23	26	32	40
Gliricidia	12	15	15	15	18	22	29	32
Anthonata mycrophylla	5	7	9	10	12	14	17	21

MAP = Months after planting

Table 2: Height of *Gnetum africanum* growing on leguminous tree species

Leucaena	26.33	35.00	50.67	65.27	80.10	97.20	110.25	135.00
Gliricidia	20.67	32.00	41.16	52.12	71.21	84.00	99.20	119.25
Anthonata mycrophylla	12.67	15.01	27.25	34.34	49.94	54.35	67.49	87.24
LSD(0.05)	3.24	3.27	3.48	3.43	3.57	4.30	4.37	4.48

Table 3: Number of vines of *Gnetum africanum* growing on leguminous tree species

Leucaena	3	3	5	6	8	10	11	13
Gliricidia	4	4	5	5	6	8	9	10
Anthonata mycrophylla	2	2	3	4	4	5	6	6
LSD(0.05)	0.02	0.21	0.24	0.27	0.28	0.29	0.31	0.37

Table 4: Proximate composition of *Gnetum africanum* vegetable (mg/100g)

Treatment	Moisture (%) SD	Crude Protein (%) SD	Lipid (%) SD	Carbohydrate (%) SD	Crude fibre (%) SD	Ash (%) SD
Raw	$86.4^{b}\pm0.33$	$5.2^{b}\pm0.16$	$0.7^{ab}\pm0.21$	$3.6^{b}\pm0.16$	$1.8^{a}\pm0.35$	$2.3^{a}\pm0.21$
Sundried	$82.2^{a}\pm0.35$	$6.1^{c}\pm0.08$	$1.3^{c}\pm0.14$	$4.3^{c}\pm0.29$	$2.7^{d}\pm0.29$	$3.4^{d}\pm0.08$
Blanched	$85.7^{b}\pm0.05$	$5.0^{b}\pm0.14$	$0.6^{a}\pm0.01$	$3.2^{a}\pm0.16$	$2.4^{c}\pm0.10$	$3.1^{c}\pm0.16$
Boiled	$76.3^{d}\pm0.21$	$4.4^{a}\pm0.36$	$0.4^{a}\pm0.\ 05$	$3.0^{a}\pm0.21$	$2.1^{b}\pm0.14$	$2.8^{b}\pm0.35$
LSD = 0.3						

Figures not followed by the same superscript are significantly different (P# 0.05)

Table 5: Mineral content of *Gnetum africanum* (mg/100g)

Treatment	K	Na	Ca	Mg	Zn	Fe	P
Raw	1.6 ^{b}±0.1	2.0 ^{c}±0.1	0.2 ^{b}±0.3	0.4 ^{b}±0.1	0.8 ^{b}±0.3	5.8 ^{b}±0.1	0.3 ^{c}±0.3
Sundried	1.5 ^{a}±0.1	1.9 ^{b}±0.1	0.2 ^{b}±0.3	0.2 ^{a}±0.3	0.8 ^{b}±0.3	5.6 ^{a}±0.1	0.2 ^{b}±0.3
Blanched	1.6 ^{b}±0.1	1.9 ^{b}±0.1	0.2 ^{b}±0.3	0.2 ^{b}±0.1	0.8 ^{b}±0.	5.7 ^{b}±0.1	0.3 ^{c}±0.3
Boiled	1.5 ^{a}±0.1	1.8 ^{a}±0.3	0.1 ^{a}±0.2	0.2 ^{a}±0.3	0.7 ^{a}±0.3	5.6 ^{a}±0.1	0.1 ^{a}±0.3
LSD = 0.3							

Figures not followed by the same superscript are significantly different (P# 0.05)

Table 6: Matrix ranking of farmer preference to live stakes (agroforestry trees) and traditional system

Criteria	Agrofroestry	Traditional System
Land tenure	6	8
Source of fuel wood	5	7
Fodder	5	8
Labour input	8	4
Soil amendment	7	3
Source of income	6	4
Source of food	3	6
Total	42	40

Source: 13.

Table 7: Variables considered in the analysis of the determinants of adoption of recommended technologies in *G. africanum* cultivation

	Variables			Remarks
1.	DV 16	Socio-economic characteristics		Yes = 1; No = 2
2.	Endogenous			
	V2	Sex of respondents:	Male (M) = 1;	Female (F) = 2
	V3	Age of respondent:	20-25 years	= 1
			26-31	= 2
			32-37	= 3
			38-43	= 4
			44-49	= 5
			50 and above	= 6
	V4	Level of education:		
		No formal education		= 1
		Primary		= 2
		Secondary education		= 3
		Polytechnic, College of Education, Agric.		= 4
		Tertiary		= 5
	V5	Household size:	Single (1)	= 1
			Small (2-4)	= 2
			Medium (5-7)	= 3
			Large (>7)	= 4
	V6	Farming experience:	< 5 years	= 1
			5-10	= 2
			11-15	= 3
			16-20	= 4
			> 20	= 5

Table 7: Continued

3.	Exogenous			
	V7		Land tenure status:	Family land = 1
	V8		Outright purchase	= 2
			Leasehold	= 3
			Tenancy	= 4
			Hiring	= 5
			Farm size (Ha):	
			<0.5	= 1
			0.5-1.0	= 2
			1.1-2.0	= 3
			2.1 - 3.0	= 4
			3.1-4.0	= 5
			> 4Ha	= 6
	V9	No. of farm (plots):	1=1; 2=2;3=3;4=4;	≥ 5=5.
	V10	Labour	Family labour = 1	
			Hired labour = 2	
			Family/ Hired labour = 3	
	V11	Access to credit: yes = 1;	No = 2	
	V12	Access to extension service	Yes = 1; No = 2	
	V 13	Off farm job: yes =1;	No = 2	
	V 14	Income (Annual average):	<N10,000 = 1	
		10,000 - 20,000 =2		
		21,000 - 30,000 = 3		
		31,000 - 40,000 = 4		
		41,000 - 50,000 = 5		
		> 50,000 = 6		
	V15 Members of	Cooperative organization:	Yes = 1; No = 2	

Source: 13.

Table 5 shows the mineral content of *G. africanum* in various sample forms. Raw sample had 1.6% of potassium, 2.0% of sodium, 0.2% of calcium, 0.4% of magnesium, 5.8% of iron, 0.3% of phosphorus and 0.8% of zinc. The sun-dried sample contained 1.5% of potassium, 1.9% of sodium, 0.2% of calcium, 5.6% of iron, 0.2% of phosphorus and 0.8% of zinc (see discussion). Similarly, the blanched sample had 1.6% of potassium, 1.9% of sodium, 0.2% of calcium, 0.2% of magnesium, 5.7% of iron, 0 .3% of phosphorus and 0.8% of zinc. In the boiled sample, potassium was 1.5% and with sodium and calcium 1.8% and 0.1% respectively. These were followed by magnesium with 0.2%, iron with 5.6%, phosphorus with 0.1% and zinc with 0.7% (see discussion).

Respondents' Preferences of Agroforestry/ Traditional Systems: A matrix ranking of the important criteria for farmers' preference is as shown in Table 6. Two areas were considered: the agroforestry system because of the use of improved live stakes *L. leucocephala*, *G. sepium*. and *A. macrophylla* and the traditional system representing shifting cultivation. Labour input was ranked the highest among the agrofroestry system. This was followed by soil amendment and land tenure and source of income respectively. However, in the traditional system, land tenure and source of fodder were rated the highest and followed by source of fuelwood and food respectively by the farmers.

Estimation of Relationships of Specific Determinants in Adoption of *G. Africanum* Technologies: The probit analysis was employed in analyzing the *G. africanum* farmers' perception on determinants to adoption (Table 7). Besides, it was used to estimate the effect that farmers' endogenous and exogenous characteristics can have in the adoption of *G. africanum* recommended technologies. The description of the variables used in the analysis and the estimated relationships are presented in Tables 7 and 8, respectively.

Table 8: Probit estimates of instrumental variables in adoption of improved *G. africanum* technologies

Variable	Coefficient	T-ratio
V2	0.96105	0.67545**
V3	-0.43733	-1.06876
V4	-0.51787	-1.07.322
V5	-0.82217	-1.28101
V6	-0.11761	-0.12218
V7	0.53686	1.93278**
V8	-0.34870	-1.26679**
V9	-0.16660	-0.52872
V10	0.50116	0.36689
V11	1.03859	1.15639
V12	-8.60529	-0.03432
V13	1.24636	1.17362
V14	0.61137	2.02133***
V15	-1.04643	-1.48291*

Source: 13.

*Significant at 0.05 level

** Significant at 0.10 level

***Significant at 0.01 level

DISCUSSION

The rate of growth of *G. africanum* in the first two years after planting was slow. But once the crop climbed the stake to a height of about 2m, it began to flourish and had an increasing number of vines. Although the live stakes for the crop to climb may have impeded sunlight, it serves as a natural environment for the crop as in the wild state. The advantage here is that the harvesting is done at regular intervals when fully grown unlike in the wild state which is done by different people, who come across it in a haphazard manner. Of course, in the wild, there is no specific owner and therefore no control. The crop so far has an advantage over other vegetable crops like *Telfaria occidentalis*, *Amaranthus* sp. *Talianum triangulare*, etc. because there are no pest and disease problems associated with its cultivation.

Generally, crude protein was higher in raw (5.2%) and blanched (5.0%) samples of *G. africanum* but highest in sun dried (6.1%) samples and however, low in boiled (4.4%) samples. However, crude protein in raw and blanched samples did not differ significantly. Sun-dried samples were significantly (P< 0.05) different from other samples (Table 4). This suggests that *G. africanum* vegetable can better be preserved and storage life prolonged through sun-drying. Lipids content in raw, blanched and boiled samples did not differ significantly. However, the lipid content in sun-dried samples was significantly (P< 0.05) different from the rest of samples. For improved nutritive intake of crude protein and lipids, the sun-dried leaves of *G. africanum* are recommended.

Carbohydrate in blanched and boiled samples did not differ significantly. However, carbohydrate contents in raw and sun-dried samples differed significantly. This showed that raw and sun-dried *G. africanum* contains more carbohydrates than in the blanched or boiled forms because the carbohydrate had been denatured in the blanched and boiled forms. It follows that *G. africanum* taken raw or in sun-dried form as in salad provides more carbohydrates. The crude fibre in the samples differed significantly (P< 0.05) in raw, sun-dried, blanched and in boiled samples. However, the sun-dried sample had the highest level of crude fibre among the samples. This again shows an added value of *G. africanum* in the sun-dried form to the diet of those that consume *G. africanum* leaves. Similarly, the samples in their various forms differed significantly in the ash content. Moisture content of the samples did not differ significantly (P<0.05) between the raw and blanched samples. But comparatively, the moisture content was significantly lower in the sun-dried sample.

The raw sample had the highest content of Vitamin C represented by 56.8%, while the sun-dried had 33.6% with 30.4 and 16.3% for blanched and boiled samples, respectively. It therefore follows that for a higher intake of Vitamin C, the raw form of G. *africanum* leaves like in salad is preferable.

Boiling significantly (P< 0.05) reduced the ascorbic acid content of *G. africanum* followed by blanching, then sun drying. Sun drying, blanching and boiling resulted in a loss of 40.8%, 46.5 and 71.3%, respectively. Vitamin C is the anti-scurvy vitamin. Lack of it results in fragile capillary walls, in bleeding gums and loosening of the teeth as well as bone joints diseases. However, the vitamin is easily destroyed during processing and cooking. To obtain efficient intake of vitamin C from *G. africanum* leaves sun-drying should be preferred to boiling and blanching processes.

In the agroforestry system, labour input is maximized. Soil amendment also requires less time and money since the trees are sources of nitrogen to the soil. With land tenure, people are still not relaxed as they are still tied to land as an inheritance. However, the agroforestry system enhances making of more money than in the traditional system. On the whole, agro- forestry was ranked the highest in terms of the seven criteria indicated by the respondent farmers. However, the predominant traditional system commonly practiced in the area shows that the farmers are still very close to the socio-cultural and economic environment in which the farmers operate.

The probit coefficients show that all the endogenous variables except sex have negative effect in the adoption process with gender of the farmer being the most important factor influencing adoption. This indicates that women are more involved in vegetable farming [8,9] than men. It is also becoming a consensus in development literature that women are a vital force to reckon with in agriculture [10]. Therefore women should be motivated to adopt the use of live stakes in *G. africanum* cultivation. Women involvements in *G. africanum* cultivation are also influenced by the size of land required. Unlike cassava cultivation, which may require a large size of land to be profitable, *G. africanum* cultivation requires a smaller plot of land and it is also making women to have access to land and even to own land permanently. Therefore, land tenure status was highly significant in the adoption of *G. africanum* farming technologies. Security of tenure is a critical variable determining incentives to conserve land quality as observed by Pandey *et al* [11].

Income of the farmers positively and significantly influenced adoption. Because *G. africanum* farming is highly profitable, farmers are willing to invest in the recommended technologies. So far, risk and uncertainties are very minimal. Although the probit coefficient of membership in farmers' cooperatives is negative, it is significant and related to adoption of *G. africanum* recommended practices.

CONCLUSION

The cultivation of *G. africanum* in the homestead has become a prominent practice by farmers in the study area. The study showed that the leaves of *G. africanum*, which are consumed by most households in the study area, are high in crude protein, fibre, lipids and in minerals. The leaves at the sun-dried, raw and blanched state were more nutritive according to the analysis conducted. Agrofroestry was ranked the highest in terms of the seven criteria for farmers' preferences. Gender had a positive and significant effect on the adoption of *G. africanum* technologies. Income, land tenure and membership in cooperative societies had a significant effect on adoption of improved *G. africanum* practices.

Recommendation: It is recommended that women should be given more attention because they have proved to be taking vegetable cultivation in general and *G. africanum* cultivation in particular seriously and as a sustainable crop. According to Saito [12] the potentials of women will be more valuably tapped if they are assisted to cultivate the land. Training in the processing of the leaves for home dishes should be conducted for women so as to obtain the maximum nutritive values from the *G. africanum* leaves. Besides, training on marketing should also be conducted for the farmers so as to sustain their income from the crop. Training in the use of live stakes as a mark of agro-forestry for soil amendment should be continued.

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