Original Research Article

Organoleptic and Horticultural Characterization of Selected Elite Cultivars of Plantain (*Musa paradisiaca L.*) for Value Addition and Food Security in Nigeria

Abstract

Aims: To determine and identify the organoleptic and horticultural characteristics of elite plantains cultivars that can be explored and exploited for value addition in plantain for increase income and food security in the rain forest ecology of Nigeria.

Study Design: The study was a survey of sensory perception and evaluation of value addition in elite plantain cultivars.

Place and Duration of Study: The study was carried out twice (September and October) in 2015 in Ugep, Yakurr Local Government Area with 30 members (15 males and 15 females) each from Young Farmers Multipurpose Cooperative Society and Toyojesam Multipurpose Cooperative Society in Ugep and with 30 members of Henshaw Town Fadama Community Association in Esierebom, Calabar south Local Government Area of Cross River State, respectively.

Methodology: Organoleptic characteristics of elite plantain cultivars were determined through sensory evaluation and perception of their value added products and subsequent completion of structured questionnaires which included a 5-point scale for measurement. Horticultural characteristics were determined using morphological markers (quantitative and qualitative traits measurement). Pulp hardness was measured with crossbow penetrometer while pulp/skin weight ratios were determined by taking the ratio of pulp weight to skin weight. The Genstat software was used for the analyses of data generated from the study.

Results: showed that the overall acceptability percent index for plantains chips was 100% for Ebi Egome cultivar. Other cultivars such as Mgbeghe, Enugu black and Owomoh plantain also showed significantly high acceptability percent index for chips value addition. Elite cultivars such as Ikpobata (1.1%), Ogoni Red and kigwa brown showed significant low overall acceptability percent index. The results also showed that the overall acceptability percent index for plantains flour was 96.7% for Mgbeghe cultivar. Other cultivars such as Enugu black, Ejorgom and Ekumkwam cultivars also showed significant higher acceptability percent index for flour value addition. Cultivars such as Ikpobata (3.33%), Ogoni Red and kigwa brown showed significant low overall acceptability percent index.. Results further showed that the overall acceptability percent index for value addition into plantains fufu was 97.6% for Ikpobata cultivar. Other cultivars such as Ebi egome, Ekumkwam, Mgbeghe, Enugu black and Bakpri plantain also showed significant high acceptability percent index for fufu value addition. Cultivars like Owomoh, Kainjen and Uhom scored below average in the overall acceptability percent index for value addition as fufu.

The overall acceptability percent index for Dodo-kido was 96.7% for Ebi egome and Kenkwa cultivars, 91.7% for Enugu black and 90% for Kainjen respectively. Ikpobata (cooking banana) and Bakpri (Mutant dwarf) cultivars scored significantly low values of 3.3% and 41.7% acceptability percent index for value addition as Dodo-kido. The overall acceptability percent index for value added roasted plantain was 100% for Ebi egome, Enugu black, Mgbeghe, Kainjen, Owomoh and Ejorgom cultivars. Cultivars such as Ikpobata and Bakpri showed significantly very low overall acceptability percent index for value addition as roasted plantain. Results of pulp hardness showed that cultivars such as Enugu black plantain, Mgbeghe and Kenkwa had the most hardened pulps with an average pulp hardness of 1.9 – 1.7kg/cm³.. The least pulp hardness of 1.3 – 1.1kg/cm³ and 1.1 – 0.9kg/cm³ were measured from Bakpri and Ikpobata cultivars respectively. The results also revealed that the highest pulp/skin weight ratio of 1.5 – 1.7 was obtained from Mgbeghe cultivar while the least pulp/skin weight ratio of 1.02 – 1.15 was obtained from Bakpri cultivar.

Conclusion: Though numerous cultivars of plantain exist in the region, not all can be used in value addition for commercial purpose if increase in income and food security is to be achieved. This research will therefore serve as a guide to farmers, processors, marketers and consumers alike in the choice of plantain cultivars for different value addition for commercial purposes and consumption. It will also serve a baseline information and guide to farmers and processors on the best way to add value to plantains especially where their own cultivars have comparative advantage over other

cultivars in any particular value addition process. This will increase their income and ensure food security by reducing waste and losses.

Key words: Sensory evaluation, acceptability index, food quality and security**.**

INTRODUCTION:

Plantain (*Musa paradisiaca* L.) is a giant perennial herb of the genus *Musa*. It is one of the most versatile food crops in the tropics, where it is seen as a very important component of food security and provides a substantial amount of income to local farming communities through internal trade [1,2]. The crop is of extraordinary significance with a bright economic horizon in West and Central Africa and Latin America, which are the predominant plantain growing regions of the world. It is one of the few most important suppliers of dietary energy in parts of the humid forests and mid-altitude agro-ecologies of tropical regions of the world, where it is cultivated and utilized as a major starchy staple and consumed by nearly half a billion people in different parts of the world [1,2].

Nigeria is one of the major plantain producing countries [3,4]; fuelled in part by the tremendous rate of consumption in the country as a result of the rapidly increasing urbanization rate and the great demand for easy and convenient foods by the non-farming urban people [4].

Nigeria is the largest producer of plantain in West Africa with an estimated annual production rate of about 12.4 million metric tonnes. Most part of the country is characterized by a tropical rain forest, even rainfall distribution and soil conditions that favours the cultivation and production of the crop [4,5].

The overall objective of agricultural development and one of the Sustainable Development Goal is to ensure adequate food production and security, expand export crop production, raw material production for domestic industries and create rural employment opportunities for a rapidly increasing rural and urban population. Hence, food must be provided in sufficient and wholesome forms to meet the ever increasing demand [5].

The emerging technological drive in food processing has made food sufficiency and availability possible for developed nations. These innovations in storability and food processing need to be adopted in third World nations if the object of food security is to be achieved [6].

About one hundred and sixteen (116) plantain cultivars are presently reported to be under cultivation in Africa and these vary from one country to the other as well as between geographical localities within the same country [4,5,6].

The versatility of plantain fruit crop in the kitchen as well as its medicinal and industrial uses (both peel and pulp) have attracted a lot of interest of the agriculturist, nutritionist, horticulturist and breeders to the crop in recent years. Plantain is a good source of carbohydrate, protein, iron and other minerals. It is very rich in potassium and pro-vitamin A (Carotene). Gastro intestinal disorder like diarrhea and vomiting can be treated with plantain. Studies by Ganry [7] suggest that plantain diet is good for diabetic patients, the obese, gall stone disease, coronary heart disease and colon cancer. Its sodium level is low and therefore is recommended in the formulation of low sodium diet.

Apart from the nutritional and medicinal importance of plantain as highlighted above, plantain products marketing has provided enormous jobs for the teeming jobless youths and unskilled women who make money selling plantain products with added value in salted and peppered plantain chips, roasted plantain, plantain flour and plantain filtrates to motorist and travelers in almost all the express highway routes in Nigeria [7,8,9]. Plantain products are a major food products sold in every motor parks, high traffic hold ups, filling stations, office premises, schools, hospitals, churches, mosques as quickened food and snacks for any time of the day, thus creating jobs and generating income for the stakeholders.

Value addition in plantain has taken a new dimension due to the dietary importance and income associated with marketing of plantain snacks products which has increase the demand for its products [9,10]. Value is added to plantain as plantain chips (salted), plantain chips (salted and peppered), plantain filtrates (dough), plantain flour, plantain fufu, plantain pastry, plantain porridge, boiled plantain, roasted plantain, and fried plantain (dodo).

The object of this study, was therefore design to expose the horticultural and organoleptic characteristics of the prominent plantain cultivars in the study area which should serve as a basis for adding value to plantain to ensure longer shelf life of products, increase palatability and acceptability of the value added products thereby leading to a sustainable increase in income and utility for the processors, marketers, farmers and consumers. This research will be able to direct processors and consumers alike on the best cultivar(s) to use for the different value added products in plantain for

food security, sustainable income and improve standard of living and satisfaction of the consuming public.

2.0. **Materials and Methods**

2.1. Study location

The study was carried out twice in September and October of 2015 in Ugep, Yakurr Local Government Area with 30 members (15 males and 15 females) each from Young Farmers Multipurpose Cooperative Society and Toyojesam Multipurpose Cooperative Society in Ugep and with members of Henshaw Town Fadama Community Association in Esierebom, Calabar south Local Government Area of Cross River State, respectively.

2.2. Sources of experimental materials

Fourteen (14) cultivars of plantain were used for the study (Table 1). They were obtained from *in situ* identification of over 300 plantain accessions locally maintained by farmers in the rain forest ecology of Nigeria. Over 300 plantain accessions were assessed and evaluated *in situ* for their agronomic and yield performance registering their coordinates (GPS readings).

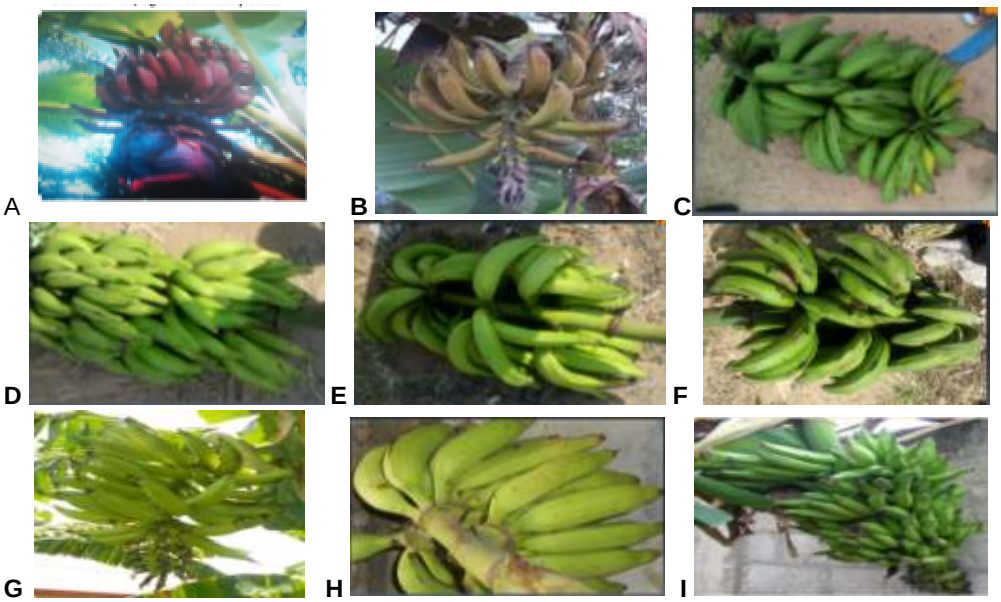
The generated data were subjected to cluster analysis using a Genstat software from which the 14 elite cultivars used in the study were generated and characterized. Both quantitative and qualitative attributes were used in the grouping of accessions into the 14 major cultivars.

Coordinates for the 14 major elite cultivars generated and identified were collected in areas of most abundance of each cultivar with their local names (Table 1).

Table 1: Latitudes, longitudes and altitudes of 14 elite plantain cultivars used for the study.

Elite plantain cultivars	Latitude (N)	Longitude (E)	Genome/type	Altitude (masl)
1. Enugu Black	06° 02.835’	008° 41. 104’	False horn /AAB	210m
2. Ebi Egome	05° 56.540’	008° 50. 457’	False horn /AAB	131.98m
3. Ogoni Red	06° 54.583’	009° 17. 799’	French /AAB	178m
4. Kigwa Brown	06° 48.617’	009° 15. 301’	False horn/AAB	183m
5. Ejorgom	06° 30.723’	009° 10. 687’	True horn/AAB	119m
6. Bakpri (dwarf mutant)	04° 97.778’	008° 36. 013’	French/AAB	54m
7. Owomoh	05° 55.882’	008° 26. 391’	True horn/AAB	175m
8. Kainjen	05° 58.200’	008° 63. 520’	False horn/AAB	181m
9. Ikpobata (cooking banana)	06° 28.427’	009° 08. 845’	French/ABB	97m
10. Mgbeghe	05° 38.710’	008° 46. 024’	False horn/AAB	119m
11. Kenkwa	06° 04.445’	008° 54. 776’	False horn/AAB	129.6m
12. Uhom	05° 42.188’	008° 03. 233’	False horn/AAB	56m
13. Ekunkwam	06° 33.462’	008° 52. 290’	French/AAB	110m
14. Ingwam	06° 39.995’	008° 51. 607’	French/AAB	92m

masl = meters above sea level.



J K L

M N

A = Ogoni Red French
B = Kigwa Brown False Horn
C = Enugu Black False Horn
D = Ebi Egome False Horn
E = Owomoh True Horn
F = kenkwa False Horn
G = Kainjen False Horn
H = Uhom False Horn
I = Ekumkwam French
J = Ikpobata French
K = Mgbeghe False Horn
L = Ingwam French
M = Bakpri French
N = Ejorgom True Horn

2.3. Value addition processes in elite plantain cultivars

Different value addition processes are currently being adopted for the different plantain cultivars in different localities in Nigeria because of the prevailing customs and traditions and purposes. However, the interest of this research was focused on the value addition process that has general acceptability. Some of these values include

1. Ripe Fried plantain (Dodo-kido)
2. Fried Plantain chips (ripe)
3. Fried plantain chips (unripe)
4. Boiled plantain
5. Roasted plantain
6. Plantain flour
7. Plantain pastry

2.4. Process methodologies for value additions in plantain

2.4.1. Boiled plantain

The fingers of ripe or unripe plantain were peeled and cooked in boiling water or vapour for 20 to 50 minutes depending on the cultivar and ripening stage of the fruit. Fingers boiled in this way are consumed with various sauces or other accompanying dishes. This mode of cooking and eating is quite common in most plantain producing communities in Nigeria [8,11].

Green mature fruits after peeling were cooked in water and mixed with palm oil, cow leg meat, salt and diverse spices (scent leaves). This is a classical dish for the people of West, Southern Nigeria during weddings, funerals and other traditional ceremonies. The pulp of unripe plantains cut into pieces can also be cooked with water, salt, palm or groundnut oil, groundnut paste, tomatoes and spices, fresh or smoked fish or meat. This makes a porridge or one-course meal [12].

2.4.2. Plantain pastry (fufu)

Unripe plantain pulp after cooking in water or vapour was pounded in a wooden mortar and transformed into a homogenous flexible pastry. According to IITA report [13], the addition of a flour of cocoyam or cassava was done to improve the elasticity of the plantain pastry which is always dark. Plantain fufu is very dark in colour when cooked and as such usually blended or mixed with cocoyam, yam or cassava to give a homogenous pastry as fufu.

2.4.3. Roasted plantains

The entire pulps of unripe or half-ripe plantains are peeled and roasted on heated charcoal. About 15 minutes is enough to prepare simultaneously 3 to 6 fingers of plantain depending on the customers. Women and youths on the roadside generally sell this plantain which is consumed warm with other delicacies like roasted plums, roasted fish, bush meat, etc. The cooking and selling of roasted plantain constitutes a major commercial activity for some youths and women in rain forest ecology of Nigeria and other plantain producing and non-producing regions [14].

2.4.4. Fried plantains

Ripe or unripe plantain are peeled and cut into slices and fried in palm oil or other vegetable oil for 4 to 5 minutes at 160-180℃. Ripe fried plantains are usually eaten with fried beans, roasted fish, chicken or bush meats are sometimes served. Fried ripe plantain or dodo in Nigeria, aloko in Côte d'Ivoire and red-red in Ghana is a meal well cherished by children and adult in motor parks and restaurants [15].

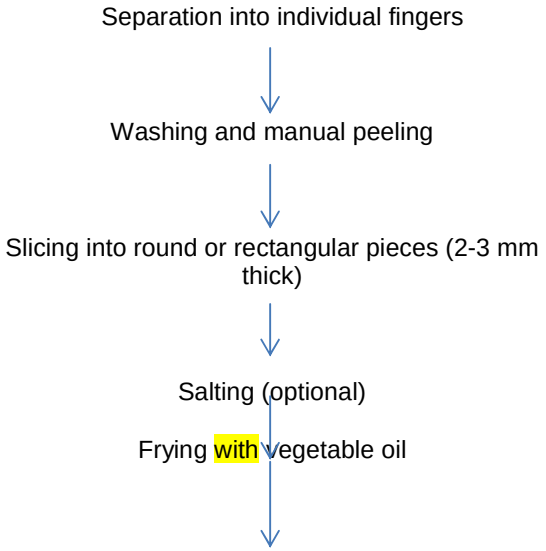
2.4.5. Plantain fritters (Dough)

The pulp of over ripe plantains are pounded and mixed with a small quantity of wheat or other local cereal flour (about 1/4 of pulp weight) and salted to form a homogeneous pastry. The fritters were prepared by deep frying of small pastry balls in palm oil (160-180℃ for 4 to 5 minutes). Njoku and Nweke [16] observed that the prepared fritters are eaten hot or warm alone or with other dishes (sauce, spices, fried beans, etc).

2.4.6. Plantain Chips (salted, salted and peppered optional)

Plantain chips are the most popular plantain products in Nigeria [17,18]. There are prepared by frying round or rectangular slices of unripen or slightly ripened plantain pulp in vegetable oil. Best quality plantain chips can be obtained by frying round or rectangular slices of pulp (1 - 2 mm thick) in refined palm oil between 160 and 170℃ for 2 to 3 minutes [19, 20]. The anti-oxidizing treatment (soaking in citric acid solution) which is indispensable to inhibit the action of polyphenol-oxydase responsible for the browning of the pulp of plantain before frying is not necessary when making chips from plantains [21,22]. The plantain chips prepared in this way and packed in plastic sachets or in hermetic aluminum sachets can stay longer and conserve all their quality for more than 4 weeks at room temperature and away from light. Generally, they contain less than 35 percent of fats and between 1 to 3 percent residual humidity.

Plantain chips production process flow schematic diagram



(Refined palm oil, 2 to 3 minutes at 160-170℃)

↓

Plantain chips (golden colour)

↓

Draining and cooling

↓

Hermetic packaging

↓

(Plastic or aluminum sachets)

2.4.7. Plantain flour: The process of plantain flour and plantain fufu production can be presented using a simple schematic flow diagram as presented below.

Green mature plantain fruit

Hand peeling → **Peels separated for soap pulps**

↓

Soaking pulps in tank

↓

Slicing pulps into smaller units

↓

Drying → **Dried**

↓

Milling → **Hammer Mill**

↓

Sieving → **to removes stones and dirts**

↓

Flour → **flour to plantain fufu**

↓

Branded Nylon → **Nylon packaging**

↓

Packaging

Process flow diagram for processing unripe plantain fruit into plantain flour.

2.5. Determination of pulp hardness in kg/cm³

Hardness of the pulp is measured at the median transverse cut of fingers using a crossbow penetrometer of Cosse type model with a 6mm diameter nozzle [23]. This equipment was used to determine the pulp hardness in kg/cm³. Pulp hardness determination was done in triplicates for each elite plantain and the mean hardness recorded. Pulp hardness depends on the age of plantain fruit and moisture content of fruit at the time of harvest. Physiologically matured plantain fruits will show lower pulp hardness than fully matured fruits.

2.6. Determination of pulp/skin weight ratios

An electronic weighting balance was used to measure the weight of skin (peel) in kg and the weight of the pulp in kg before dividing to get the pulp/skin weight ratios for each of the 14 elite plantain cultivars shown above. Pulp/skin weights ratio determination was done in triplicates for each elite plantain cultivar and the mean results recorded. This horticultural attributes also depends on the stage of growth and age of plantain fruit at harvest. Fully matured fruits may show higher ratios than physiologically matured fruits.

2.7. Determination of organoleptic (sensory evaluation) characteristics of value added plantain products

The acceptability scale measuring 1 to 5 (1=Extremely dislike, 2= Moderately dislike, 3=Neither like nor dislike, 4= Moderately like and 5= Extremely like) [24] was adopted to determine the organoleptic (sensory evaluation) characteristics of the value added products separately prepared from each of the elite plantain cultivars under the same conditions and ingredients and served to a panel of 60 people drawn from men, women, boys and girls between 15 – 55 years old and basically literate. A well-structured questionnaire was administered to each of the participant panelist after each value added plantain product was served. This exercise was carried out twice in 2015 in Ugep, Yakurr Local Government Area with 30 members (15 males and 15 females) each of Young Farmers Multipurpose Cooperative Society and Toyojesam Multipurpose Cooperative Society simultaneously in Ugep and in Esierebom, Calabar south Local Government Area of Cross River State, to members of Henshaw Town Fadama Community Association in Calabar South respectively.

The total entry for organoleptic attribute was summed up, averaged and recorded in tabular forms. Each attribute was expected to have a minimum average of 60 and maximum of 300 score when all participants responded to all question items on the questionnaire. However, average score per attribute could be lower than 60 when participants leave a question item blank without ticking any option from the described scale.

2.9. Overall acceptability index

The overall acceptability percent index [24,25] for each value added product was determined from the 60 panelist ability to accept to take responsibility of paying for the product if compelled to buy under conditions of equal financial capabilities. This was part of the questionnaire. A score of Sixty (60), one from each panelist will mean 100% overall acceptability percent.

3.0. Results

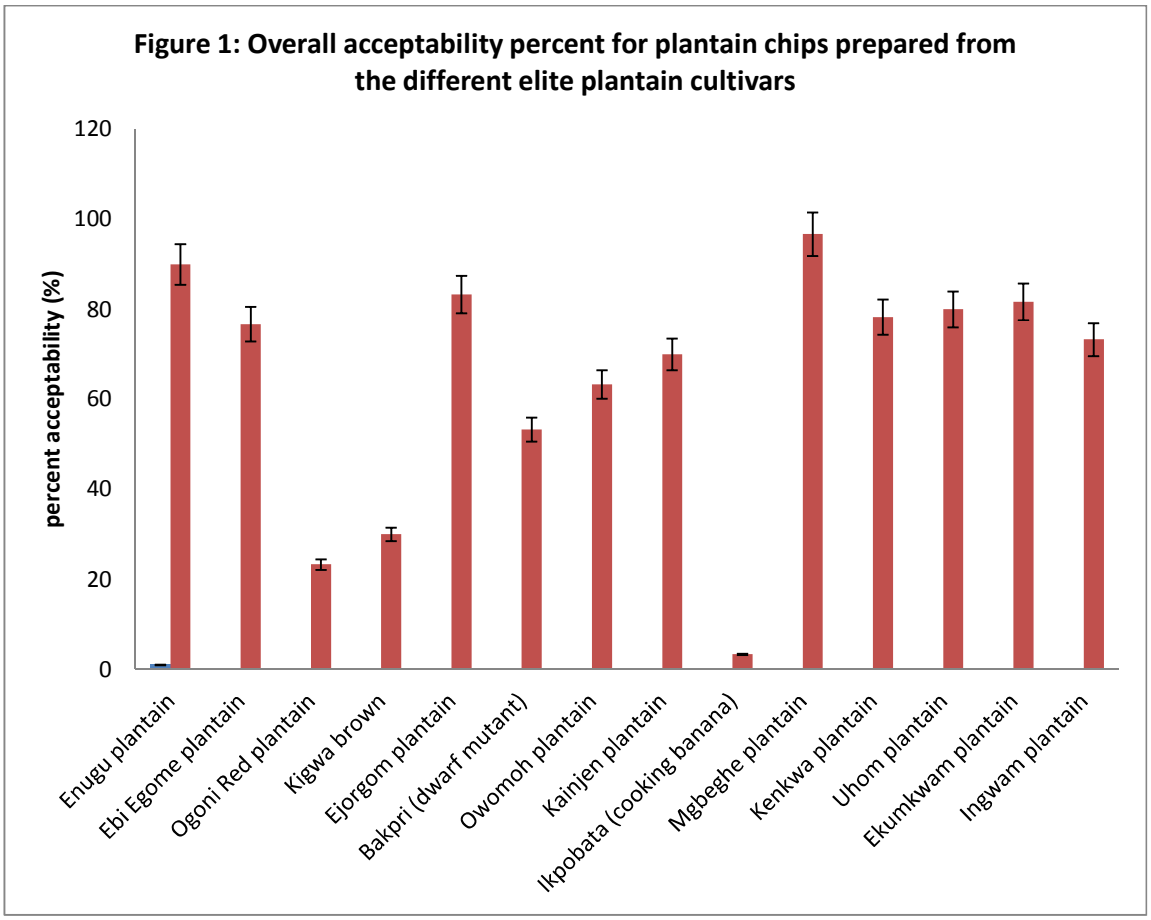
3.1. Unripe plantain chips

The results showed significant ($p<0.05$) differences in texture, flavor and palatability of chips prepared from unripe elite plantain cultivars. However, the colour of chips did not differ ($p>0.05$) significantly among the elite cultivars after value addition. Results as presented in Table 2 and Figure 1 overall acceptability percent index for plantains chips was 100% for Ebi Egome cultivar showing that this was the best cultivar for plantain chips making in this agro-ecology. Some other cultivars such as Mgbeghe, Enugu black and Owomoh plantain also showed significantly high acceptability percent index for chips value addition. Elite cultivars such as Ikpobata (1.1%) (cooking banana), Ogoni Red and kigwa brown showed significant low overall acceptability percent index and as such not recommended for value addition into plantain chips for commercial purpose in this agro-ecology.

Table 2: Means response of panelist to organoleptic evaluation of **unripe plantain chips** prepared from all the elite plantain cultivars

S/N	Elite plantain cultivars	Texture	Flavour	Colour	Palatability	Overall acceptability (%)
1	Enugu Black	69	80	61	63	41(68.3)
2	Ebi Egome	80	65	60	84	60 (100)
3	Ogoni Red	50	45	60	48	4 (6.67)
4	Kigwa Brown	66	65	62	57	5 (8.3)
5	Ejorgom	65	63	62	64	34 (56.7)
6	Bakpri (dwarf mutant)	42	63	60	62	3 (5)
7	Owomoh	54	46	62	54	50 (83.3)
8	Kainjen	53	55	61	48	34 (56.7)
9	Ikpobata (cooking banana)	23	21	61	29	1(1.67)
10	Mgbeghe	66	58	60	62	52 (86.7)
11	Kenkwa	60	42	60	64	38 (63.3)
12	Uhom	32	36	60	43	15 (25)
13	Ekumkwam	63	53	62	55	18 (30)
14	Ingwam	60	52	62	60	30 (50)
	LSD (0.05)	3.55*	2.12*	NS	2.87*	

*Significant differences at ($p<0.05$). NS = not significant at 5 percent.



3.2. Plantain flour

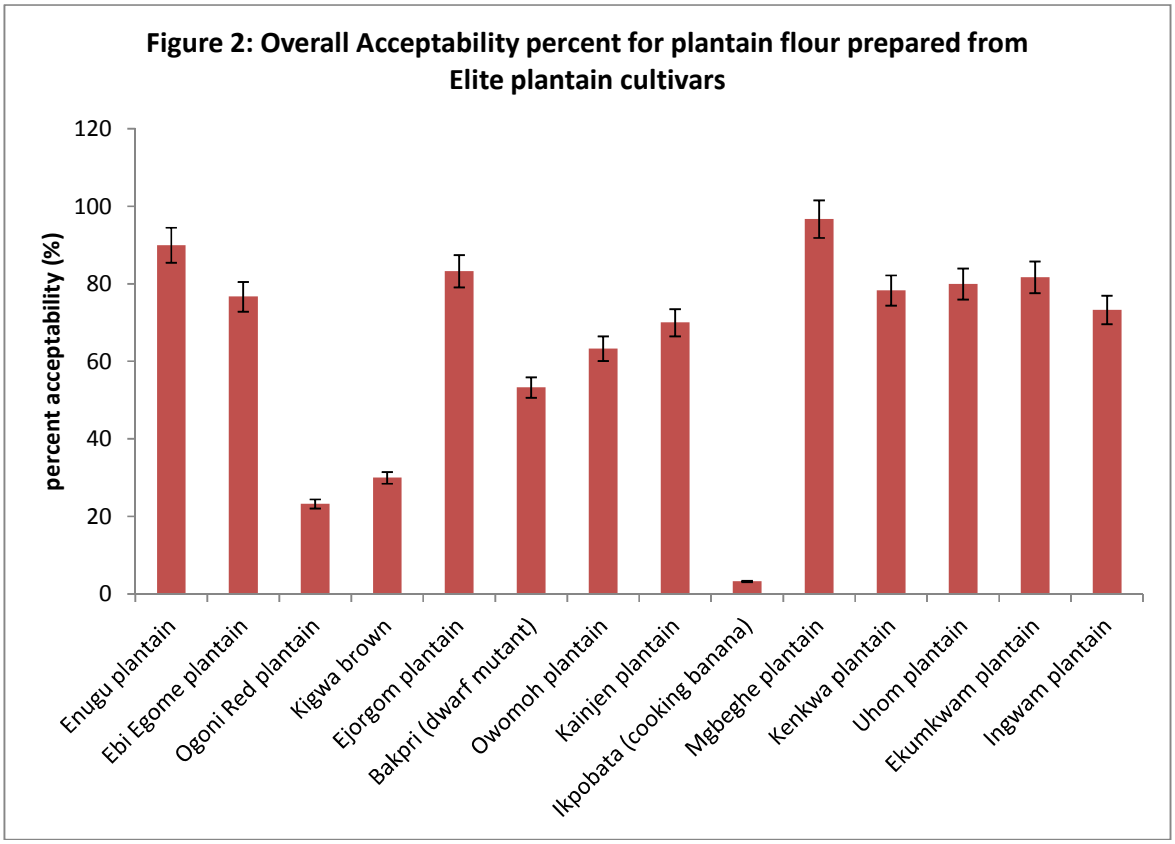
The results showed significant ($p<0.05$) differences in texture, colour, flavor and taste of flour prepared from the elite plantain cultivars after value addition. Results as presented in Table 3 and Figure 2 overall acceptability percent index for plantains flour was 96.7% for Mgbeghe cultivar indicating that this was the best cultivar for plantain flour making in this agro-ecology. Some other cultivars such as Enugu black, Ejorgom and Ekumkwam cultivars also showed significantly high acceptability percent index for flour value addition. However, elite cultivars such as Ikpobata (3.3%) (cooking banana), Ogoni Red and Kigwa Brown showed significant low overall acceptability percent index and not recommended for used for commercial flour production.

Table 3: Means response of panelist to organoleptic evaluation of **plantain flour** prepared from all the elite plantain cultivars

S/N	Elite Plantain cultivars	Texture	Flavour	Colour	Taste	Overall Acceptability	Percent acceptability (%)
1	Enugu Black plantain	95	120	300	280	54	90
2	Ebi Egome plantain	80	115	300	265	46	76.7
3	Ogoni Red	70	10	300	155	14	23.3
4	Kigwa Brown plantain	70	40		150	18	30
5	Ejorgom plantain	95	120	300	184	50	83.3
6	Bakpri Plantain	70	40	295	150	32	53.3
7	Owomoh Plantain	80	95	295	195	38	63.3
8	Kainjen Plantain	85	85	300	185	42	70
9	Ikpobata plantain	80	25	298	60	2	3.33
10	Mgbeghe Plantain	98	120	300	280	58	96.7
11	Kenkwa Plantain	90	115	300	260	47	78.3
12	Uhom Plantain	85	110	299	204	48	80

13	Ekumkwam Plantain	120	90	296	180	49	81.7
14	Ingwam Plantain	75	65	300	180	44	73.3
	LSD (0.05)	5.11*	4.23*	3,08*	7.06*		

*Significant at p<0.05. NS = Not significant at 5 % probability.



3.3. Plantain fufu

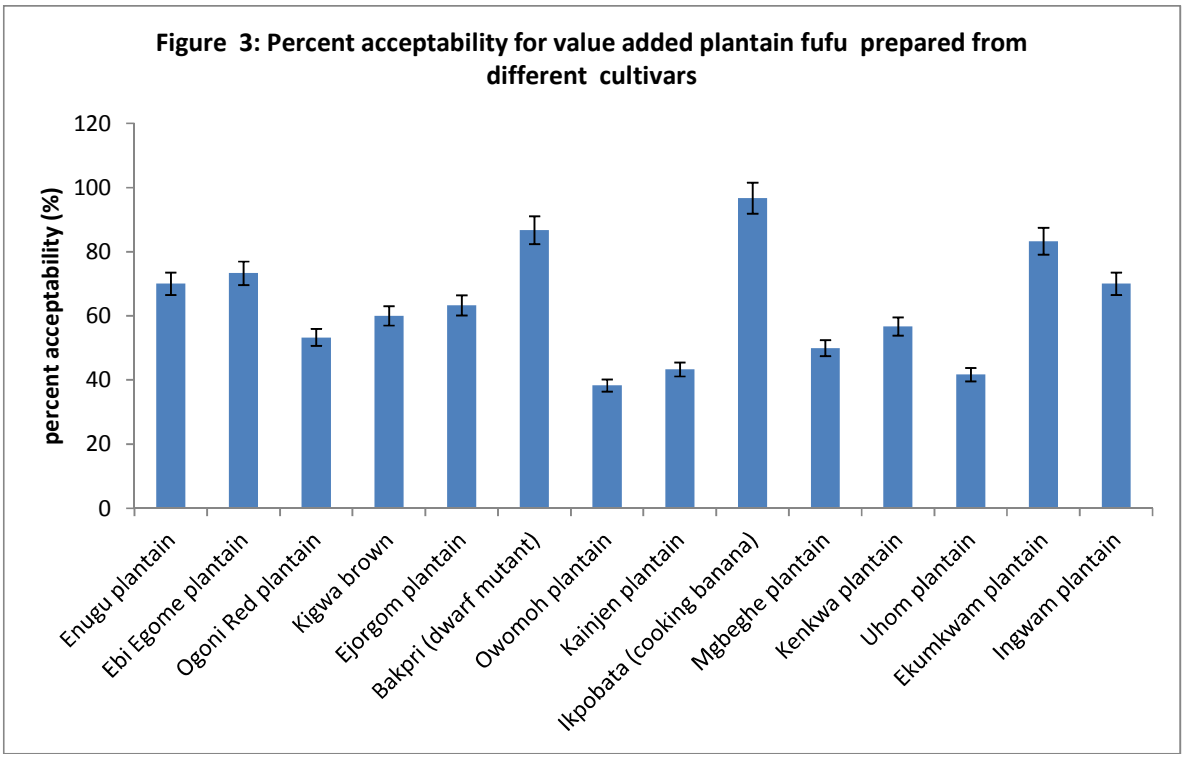
The results showed significant (p<0.05) differences in texture, flavor and palatability of fufu prepared from unripe elite plantain cultivars. However, the colour of fufu did not differ (p>0.05) significantly among the elite cultivars after value addition as all were blackening after about 30 minutes of value addition. To ensure homogeneity and acceptability, equal amount of cocoyam fufu was used to mix with each of the cultivar. Results as presented in Table 4 and Figure 3 show that the overall acceptability percent index for plantains fufu was 97.6% for Ikpobata (cooking banana) cultivar showing that this was the best cultivar for plantain fufu making because of its tasteless quality in this agro-ecology. Some other cultivars such as Ebi Egome, Ekumkwam, Mgbeghe, Enugu black and Bakpri (dwarf mutant) plantain also showed significantly high acceptability percent index for fufu value addition. Others like Owomoh, Kainjen and Uhom of the elite cultivars scored below average in the overall acceptability percent index and is not recommended for used for commercial plantain fufu production in the agro-ecology.

Table 4: Means response of panelist to organoleptic evaluation of **plantain fufu** prepared from all the elite plantain cultivars

S/N	Elite plantain cultivars	Texture	Flavour	Colour	Palatability	Overall acceptability	Percent acceptability
1	Enugu Black	69	80	61	63	42	70
2	Ebi Egome	80	65	70	84	44	73.3

3	Ogoni Red	50	45	70	48	32	53.3
4	Kigwa Brown	66	65	67	57	36	60
5	Ejorgom	65	63	62	64	38	63.3
6	Bakpri	42	63	50	62	52	86.7
7	Owomoh	54	46	54	54	23	38.3
8	Kainjen	53	55	54	48	26	43.3
9	Ikpobata	23	21	20	29	58	96.7
10	Mgbeghe	66	58	67	62	30	50
11	Kenkwa	60	42	60	64	34	56.7
12	Uhom	32	36	29	43	25	41.7
13	Ekumkwam	63	53	63	55	50	83.3
14	Ingwam	60	52	54	60	42	70
	LSD (0.05)	2.11*	2.98*	4.09*	5.41*		

*Significant at p<0.05. NS = Not significant at 5 % probability.



3.4. Fried ripe plantain (Dodo-kido)

The results showed significant (p<0.05) differences in flavor and palatability of Dodo-kido prepared from ripe elite plantain cultivars. However, the texture and colour of the value added Dodo-kido did not differ (p>0.05) significantly among the elite cultivars used. Results as presented in Table 5 and Figure 4 overall acceptability percent index for Dodo-kido was 96.7% for Ebi Egome and Kenkwa cultivars, 91.7% for Enugu black and 90% for Kainjen, respectively. A high proportion of the cultivars scored significantly high acceptability percent index for this value added product and thus are best for Dodo-kido value addition which is always in high demand in this agro-ecology in the mornings and evenings. However, some other cultivars such as Mgbeghe, Enugu black and Owomoh also showed significant high acceptability percent index for dodo-kido value addition. Elite cultivars such as Ikpobata (cooking banana) and Bakpri (Mutant dwarf) cultivars scored significantly low values of 3.3% and 41.7% acceptability percent index and not recommended for used for commercial Dodo-kido production in the agro-ecology.

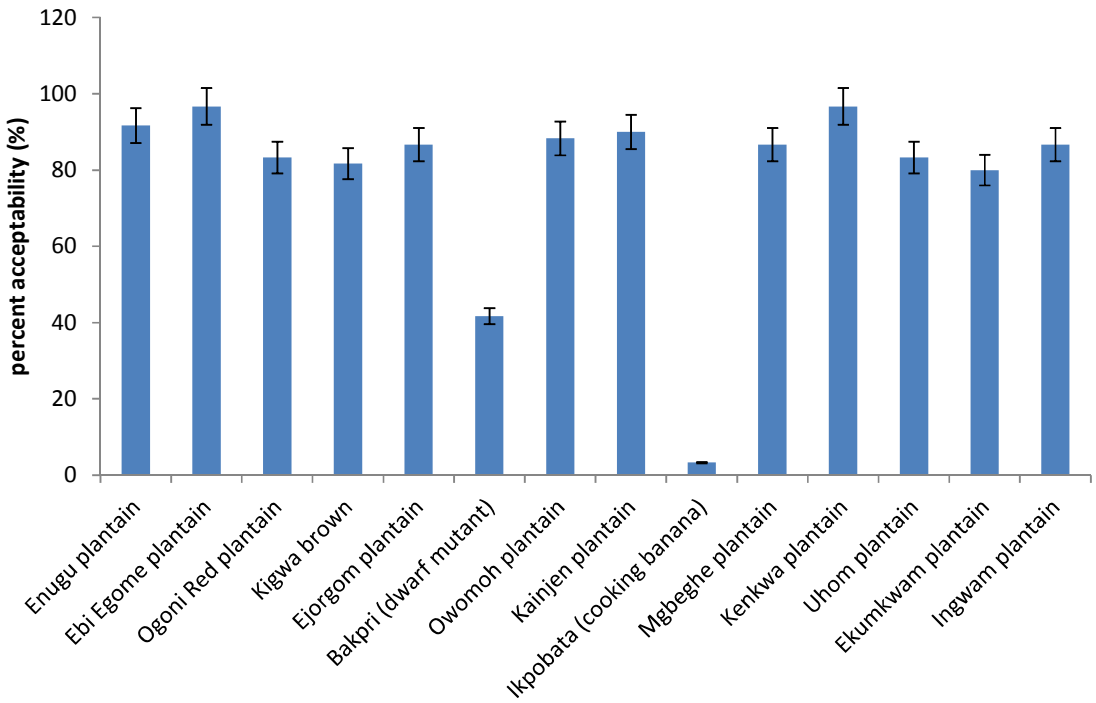
Table 5: Means response of panelist to organoleptic evaluation of **fried ripe plantain (dodo)** prepared from all the elite plantain cultivars

S/N	**Elite plantain**	Texture	Flavour	Colour	Palatability	Overall	Percent

	cultivars					acceptability	acceptability
1	Enugu Black	240	80	120	63	55	91.7
2	Ebi Egome	240	65	120	84	58	96.7
3	Ogoni Red	240	45	119	48	50	83.3
4	Kigwa Brown	238	65	120	57	49	81.7
5	Ejorgom	241	63	121	64	52	86.7
6	Bakpri	240	63	120	62	25	41.7
7	Owomoh	241	46	120	54	53	88.3
8	Kainjen	240	55	120	48	54	90
9	Ikpobata	240	21	120	29	2	3.3
10	Mgbeghe	241	58	119	62	52	86.7
11	Kenkwa	241	42	121	64	58	96.7
12	Uhom	241	36	121	43	50	83.3
13	Ekumkwam	240	53	120	55	48	80
14	Ingwam	240	52	120	60	52	86.7
	LSD (0.05)	NS	2.97*	NS	6.24*		

*Significant at p<0.05. NS = Not significant at 5 % probability.

Figure 4: Percent acceptability for value added fried ripe plantain (Dodo-kido) prepared from different elite cultivars



3.5. Roasted plantain

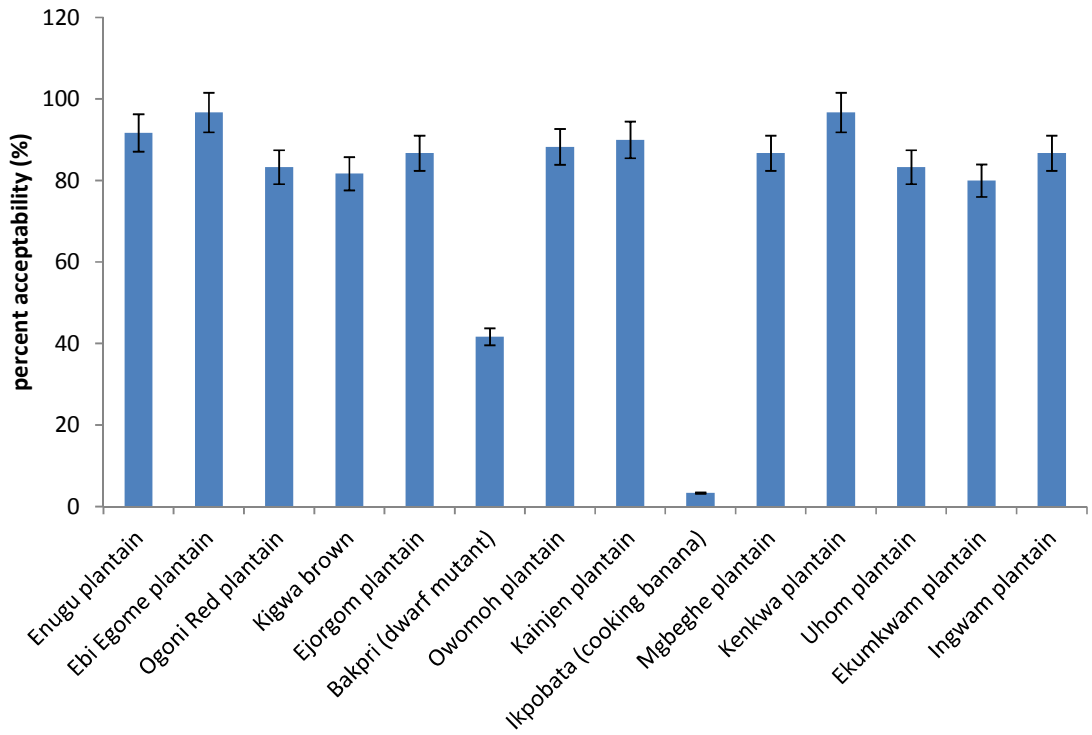
The results showed significant (p<0.05) differences in colour, flavor and palatability of chips prepared from unripe elite plantain cultivars. However, the texture of roasted plantain did not differ (p>0.05) significantly among the elite cultivars after this value addition. Results as presented in Table 6 and Figure 5 The overall acceptability percent index for value added roasted plantain was 100% for Ebi Egome, Enugu black, Mgbeghe, Kainjen, Owomoh and Ejorgom cultivars thus showing these cultivars as the best for value added roasted plantains in this agro-ecology for increase income. Majority of the elite cultivars scored high acceptability percentage index for this value addition in plantain. However, elite cultivars such as Ikpobata (cooking banana) and Bakpri (dwarf mutant) showed significantly very low overall acceptability percent index and therefore not recommended for used for commercial roasted plantain value addition.

Table 6: Means response of panelist to organoleptic evaluation of **roasted plantain** prepared from all the elite plantain cultivars

S/N	Elite plantain cultivars	Texture	Flavour	Colour	Palatability	Overall acceptability	Percent acceptability
1	Enugu Black	79	80	61	63	60	100
2	Ebi Egome	80	65	70	84	60	100
3	Ogoni Red	80	45	70	48	58	96.7
4	Kigwa Brown	81	65	67	57	52	86.7
5	Ejorgom	80	63	62	64	60	100
6	Bakpri	79	63	50	62	24	40
7	Owomoh	80	46	54	54	60	100
8	Kainjen	80	55	54	48	60	100
9	Ikpobata	81	21	20	29	1	2
10	Mgbeghe	79	58	67	62	60	100
11	Kenkwa	80	42	60	64	56	93.3
12	Uhom	80	36	29	43	48	80
13	Ekumkwam	80	53	63	55	53	88.3
14	Ingwam	80	52	54	60	54	90
	LSD (0.05)	NS	10.23*	4.51*	3.06*		

*Significant at p<0.05. NS = Not significant at 5 % probability.

Figure 5: Percent acceptability for value added roasted plantain prepared from different elite cultivars



3.6. Pulp hardness and pulp/skin weight ratios (unripe)

The results presented (Table 9) showed significant (p<0.05) differences amongst the cultivars. Elite cultivars such as Enugu black plantain, Mgbeghe and Kenkwa had the highest hardened pulps values with an average pulp hardness of 1.9 – 1.7kg/cm³. These were closely followed by Ebi Egome and Ekumkwam cultivars which showed pulp hardness of 1.8 – 1.6kg/cm³. The lowest pulp hardness of 1.3 – 1.1kg/cm³ and 1.1 – 0.9kg/cm³ were measured from Bakpri (dwarf mutant) and Ikpobata (cooking banana) cultivars, respectively.

The results of the analysis of horticultural characteristics for pulp/skin weight ratios for the elite plantain cultivars (Table 9) also showed significant (p<0.05) differences among the cultivars. From

this study, the highest pulp/skin weight ratio of 1.5 – 1.7 was obtained in Mgbeghe cultivar while the lowest pulp/skin weight ratio of 1.02 – 1.15 was obtained in Bakpri (mutant dwarf) cultivar.

Table 9: Mean measurements of horticultural properties of pulp hardness (kg/cm3) and pulp weight/skin weight ratios of elite plantain cultivars

S/N	Elite plantain cultivars	GPS reading /locations	Genome /type	Pulp hardness in kg/cm³	Pulp/skin weights ratio
1	Enugu Black	06°02.835' N 008°41. 104' E	AAB False horn	1.9 – 1.7	1.3-1.5
2	Ebi Egome	05°56.540'N 008°50. 457'E	AAB False horn	1.8-1.6	1.3-1.5
3	Ogoni Red	06°54.583'N 009°17. 799'E	AAB French Plantain	1.4 -1.1	1.2-1.3
4	Kigwa Brown	06°48.617'N 009°15. 301'E	AAB True Horn	1.4-1.1	1.2-1.3
5	Ejorgom	06°30.723'N 009°10. 687'E	AAB French Type	1.7-1.5	1.3-1.3
6	Bakpri	04°97.778'N 008°36. 013'E	AAB False Horn	1.3-1.0	1.02-1.15
7	Owomoh	05°55.882'N 008°26. 391'E	AAB False Horn	1.7-1.5	1.3-1.4
8	Kainjen	06°28.427'N 009°08. 845'E	AAB False Horn	1.7-1.5	1.3-1.4
9	Ikpobata	06°28.427'N 009°08. 845'E	ABB French plantain	1.1-0.9	1.14-1.3
10	Mgbeghe	05°38.710'N 008°46. 024'E	AAB False Horn	1.9-1.7	1.5-1.7
11	Kenkwa	06°04.445'N 008°54. 776'E	AAB False Horn	1.9-1.7	1.4-1.6
12	Uhom	05°42.188'N 008°03. 233'E	AAB True Horn	1.7-1.5	1.2-1.4
13	Ekumkwam	06°33.462'N 008°52. 290'E	AAB False Horn	1.8 -1.6	1.4-1.6
14	Ingwam	06°39.995'N 008°51. 607'E	AAB False Horn	1.7 -1.5	1.3-1.5
	LSD (0.05)			**0.21***	**0.16***

Results are mean range of triplicate measurements for each elite cultivar.

3.6. Summary of some organoleptic (sensory evaluation) and horticultural characteristics of elite plantain cultivars used in this study

The organoleptic characteristics of the 14 elite plantain cultivars was determined using sensory evaluation and perception of 60 respondents who after inspection and subsequent testing, completed a well-structured questionnaire designed to bring out the needed information, which is summarized in Table 10. The horticultural characteristics showed in Table 11 were obtained from the agronomic characterization of the elite plantain cultivars using morphological (quantitative and qualitative traits) markers, as well as the pulp hardness and pulp/skin weight ratios determination procedures as stated above. All qualitative colorimetric characteristics such as pulp colour, unripe pulp skin colour and pseudo-stem colour were compared with the Royal Horticultural Society colour chart.

Table10. Summary of some organoleptic characteristics of 14 elite plantain cultivars obtained through perception and sensory evaluation

s/n	Elite plantain cultivars	Taste of cooked pulp	Texture of peeled pulp	Taste of ripe pulp	Aroma	Palatability	General acceptability	Nutritional value of food	Firmness/hardness of cooked pulp
1	**Ogoni Red French**	Sweet	Rough	Sugary	Good/attractive	Good	Average	Average	Soft
2	**Kigwa Brown False Horn**	Sweet	Rough	Very sugary	Good/attractive	Good	Average	Average	Soft
3	**Enugu Black False Horn**	Sweet	Rough	Sugary	Good/attractive	Very good	High	Very High	Very hard
4	**Ebi Egome False Horn**	Sweet	Rough	Very sugary	Good/attractive	Good	Very High	Very High	Hard
5	**Owomoh True Horn**	Sweet	Rough	Sugary	Good/attractive	Very good	High	High	Hard
6	**kenkwa False Horn**	Sweet	Rough	Sugary	Good/attractive	Good	High	High	Very Hard
7	**Kainjen False Horn**	Sweet	Rough	Sugary	Good/attractive	Good	High	High	Hard
8	**Uhom False Horn**	Sweet	Rough	Very sugary	Good/attractive	Good	High	Average	Very hard
9	**Ekumkwam French**	Sweet	Rough	Sour	Good/ attractive	Good	High	High	Soft
10	**Ikpobata French (cooking bananas)**	Sour	Smooth	Sugary	Bad/ not attractive	Not palatable	Low	Low	Very soft
11	**Mgbeghe False Horn**	Very sweet	Rough	Very sugary	Good/attractive	Good	Very high	Very high	Very hard
12	**Ingwam French**	Salty	Smooth	Sweet	Good /attractive	Good	Average	High	Soft
13	**Bakpri French (dwarf mutant)**	Sweet	Rough	Salty	Good/attractive	Good	Low	Average	Very soft
14	**Ejorgom True Horn**	Very sweet	Rough	Very sugary	Good/attractive	Good	Average	Average	Soft

Table 11: Summary of horticultural characteristics of 14 elite plantain cultivars in Nigeria

Elite plantain cultivars	Average Length of cycle (months)	Finger size and shape	Average Bunch weight (kg)	Average No. of hands /bunch	Average No. of fingers /hand	Average No. of fingers /bunch	Unripe finger skin colour	Unripe pulp colour	Flower to harvest interval (days)	Shape of finger cross section	Pseudo stem colour	Bunch phenotype	Pulp hardness (kg/cm³)	Pulp/skin weight ratios
Ogoni Red French	15	Medium /curve	13.23	6	4	24	Red	Brown	69	Triangular	purple	French type	1.9 – 1.7	1.3-1.5
Kigwa Brown False Horn	14	Medium/ Curve	12.01	4	4	16	Brown	Milky white	62	Quadri Lateral	Gray	False horn	1.8-1.6	1.3-1.5
Enugu Black False Horn	15	Big /curve	23.54	8	8	64	Dark green	Creamy	71	Pentagonal	Green	False horn	1.4 - 1.1	1.2-1.3
Ebi Egome False Horn	14	Big /flat	22.13	9	9	81	Pale green	Creamy	74	Quadri Lateral	Green	False horn	1.4-1.1	1.2-1.3
Owomoh True Horn	13	Medium /flat	15.79	6	5	30	Pale green	Milky white	65	Triangular	Gray	True horn	1.7-1.5	1.3-1.3
kenkwa False Horn	14	Medium /curve	16.23	7	6	42	Pale green	Creamy	66	Pentagonal	Brown	False horn	1.3-1.0	1.02-1.15
Kainjen	15	Big /flat	19.88	8	6	48	Olive green	Whitish	62	Quadri Lateral	Brown	False horn	1.7-	1.3-

False Horn													1.5	1.4
Uhom False Horn	**13**	**Medium /curve**	**14.23**	**7**	**5**	**35**	**Pale green**	**Creamy**	**67**	**Quadri Lateral**	**Green**	**False horn**	1.7-1.5	1.3-1.4
Ekumkwam French	**14**	**Medium /flat**	**16.22**	**9**	**8**	**72**	**Dark green**	**Creamy**	**63**	**Triangular**	**Green**	**French type**	1.1-0.9	1.14-1.3
Ikpobata French (cooking bananas)	**13**	**Small /curve**	**7.21**	**4**	**4**	**16**	**Dark green**	**Milky white**	**69**	**Triangular**	**Brown**	**French type**	1.9-1.7	1.5-1.7
Mgbeghe False Horn	**14**	**Big /flat**	**24.97**	**6**	**7**	**42**	**Pale green**	**Creamy**	**73**	**quadrilateral**	**Green**	**False horn**	1.9-1.7	1.4-1.6
Ingwam French	**17**	**Medium /curve**	**15.64**	**6**	**5**	**30**	**Pale green**	**Creamy**	**65**	**Quadrilateral**	**Brown**	**French type**	1.7-1.5	1.2-1.4
Bakpri French (dwarf mutant)	**16**	**Small /curve**	**5.11**	**3**	**3**	**9**	**Dark green**	**Milky white**	**61**	**Triangular**	**Green**	**French type**	1.8 - 1.6	1.4-1.6
Ejorgom True Horn	**15**	**Medium /curve**	**13.80**	**6**	**5**	**30**	**Pale green**	**Creamy**	**68**	**Pentagonal**	**Brown**	**True horn**	1.7 - 1.5	1.3-1.5

Discussion

The overall acceptability percent index was significantly high for Ebi egome, Mgbeghe, Enugu black and Owomoh cultivars, indicating that these cultivars were the best for value addition into plantain chips in this agro-ecology. Ikpobata (cooking banana), Ogoni Red and kigwa brown cultivars showed significantly very low overall acceptability percent index for value addition as plantain chips and as such are not recommended for value addition as plantain chips. Many reports have shown that most of the available cultivars are good for plantain chips value addition [12,23,25 and 26] but were not specific about it. The production and marketing of plantain chips in Nigeria was formally a female activity, which has been overtaken by many jobless male youths who now venture in this as real time agribusiness since plantain chips are generally eaten as snack food at any time.

The overall acceptability percent index for plantain flour value addition was significantly high with Mgbeghe, Enugu black, Ejorgom and Ekumkwam cultivars showing that these are the best cultivars for plantain flour making in this agro-ecology. On the contrary, Ikpobata (cooking banana), Ogoni Red and kigwa brown showed significantly very low overall acceptability percent index for value addition as plantain flour. The flour is mixed with other flour from cereals for the production of biscuits and confectionaries [26, 27, 28]. It is also included in diabetic patients meals due to low content of sugar[29, 30, 31 and 32].

Results showed that the overall acceptability percent index for plantains fufu was significantly high for Ikpobata (cooking banana) cultivar showing that this was the best cultivar for plantain fufu making because of it tasteless quality in this agro-ecology. In Southern Nigeria, people are not accustomed to eat black or dark coloured fufu as found in amala in Western part of Nigeria [33,34]. This is why it is usually blended with tubers like cocoyam or cassava. This food called "fufu" in Nigeria and Ghana, "ntuba" in Cameroon and "foufou" in Côte d'Ivoire, is always eaten with a sauce which is somewhat rich in proteins. It is a staple food in certain regions of these countries [35, 36, 37].

Some other cultivars such as Ebi egome, Ekumkwam, Mgbeghe, Enugu Black and Bakpri (dwarf mutant) plantain also showed significantly high acceptability percent index for fufu value addition. Some like Owomoh, Kainjen and Uhom of the elite cultivars scored below the average in the overall acceptability percent index for value addition as fufu.

It also showed that the overall acceptability percent index for Dodo-kido was significantly high for Ebi Egome, Kenkwa, Enugu Black and for Kainjen cultivars. A high proportion of the cultivars scored significantly high acceptability percent index for this value added product and thus were the best cultivars for Dodo-kido value addition which is always on a high demand in this agro-ecology. Cultivars such as Ikpobata (cooking banana) and Bakpri (Mutant dwarf) cultivars scored significantly low acceptability percent index for value addition as Dodo-kido and therefore, are not recommended for value addition as Dodo-kido. Dodo-kido is of high demand in Southern Nigeria in the mornings and evenings and eaten with porridge beans and meat [15, 38,39]. More income is derived from value added plantain as Dodo-kido and is mostly done by women, which agrees with FAO [10] and Ukhum and Ukpebor [40].

It was further gathered that the overall acceptability percent index was significantly high for value added roasted plantain with Ebi egome, Enugu black, Mgbeghe, Kainjen, Owomoh and Ejorgom cultivars thus showing that these cultivars were the best for value addition into roasted plantains in this agro-ecology for increase income. However, elite cultivars such as Ikpobata (cooking banana)

and Bakpri (dwarf mutant) showed significantly very low overall acceptability percent index for value addition as roasted plantain. The reports of [13, 19 and 40] had also showed that women and youths on the roadside generally add value to plantain as roasted plantain which is consumed warm with other delicacies like roasted fish, roasted plums, bush meat, etc. Davies [29], FAO [33] and Ukhum and Ukpebor [40] had asserted that the cooking and selling of roasted plantain constitutes a major commercial activity for some youths and women in rain forest ecology of Nigeria and other plantain producing and non-producing regions, which was in line with our findings.

Elite cultivars such as Enugu black plantain, Mgbeghe, Kenkwa, Ebi Egome and Ekumkwam had the highest hardened pulps among the cultivars evaluated. The lowest pulp hardness was obtained from Bakpri (dwarf mutant) and Ikpobata (cooking banana) cultivars, respectively. Cultivars with hard pulps are very useful in flour, chips and pastry value additions [8, 13, 23 24, 40].

Results revealed that the highest pulp/skin weight ratio was obtained from Mgbeghe cultivar while the lowest pulp/skin weight ratio was obtained from Bakpri (mutant dwarf) cultivar. This horticultural characteristic is very important to farmers, consumers and processors as it determines yield, utility and income derived from the addition of value to the cultivars [22,14 39, 40]. Elite cultivars with higher pulp/skin weight ratios will yield more returns or products to farmers and processors compared to cultivars with low pulp/skin weight ratios [23,40].

Cultivars with pentagonal area of cross section will require more time for fruit filling than cultivars with triangular area of cross section which also tend to possess soft pulp when compared to cultivars with quadrilateral and pentagonal areas of cross sections [23, 40, 41].

Conclusion: This study has showed that though numerous cultivars of plantain exist in the region, not all can be used for value addition for commercial purpose if increase in income and food security is to be achieved. This research will therefore serve as a guide to farmers, processors, marketers and consumers alike in the choice of plantain cultivars for different value addition for commercial purposes and consumption. It will also serve as baseline information and guide to farmers and processors on the best way to add value to plantains especially where their own cultivars have comparative advantage over other cultivars in any particular value addition process. This will increase their income and ensure food security by reducing waste and losses.

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