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Comparative Study on the Agronomic, Nutritional Values and Consumer Acceptability of FHIA-21 (Tetraploid Hybrid) and Apem (Triploid French Plantain) in Ghana

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Abstract: The agronomic, nutritional composition of the green stages of fruit and the consumer acceptance of FHIA-21 (tetraploid hybrid plantain) from Honduran Agricultural Research Foundation was conducted in the forest region of Ghana. The standard AOAC methods were used to determine the moisture, crude protein, ash, crude fibre, potassium, iron, calcium, carbohydrate, sodium and crude fat. Pulp colour was measured with a Chromatometer. Results on the agronomy indicated that the hybrid was very tolerant to the black Sigatoka disease with high number of functional leaves at flowering and at harvest. The crop cycle was comparable to that of False Horn plantains. The yield performance of the hybrid was high ranging from 34-38 t ha^{-1} across the locations. The yield values have been stable over the three-year study period. In addition, the FHIA hybrid plants were relatively short. The physio-chemical composition results showed that the hybrid had high fat (1.94%) and water (60%) contents. The potassium content was also high (1060 mg/100 g dry weight) however, the iron content (0.45 mg/100 g dry weight) was low. The high potassium level in the hybrid may be an advantage for use as a therapy. The tetraploid hybrid had bright orange pulp colour which was indicative of the presence of provitamins and carotenoids. The consumer acceptability results revealed that FHIA-21 compared favourably with the local triploid (Apem). The hybrid was accepted for ampesi, fufu and ripe fried plantain. However acceptability of the hybrid as ripe fried plantain was at ripening stages 3 and 4. Beyond these stages of ripening, the hybrid could only be used for processed (mashed) food recipes.

Key words: *Musa*, FHIA-21, apem, agronomy, physio-chemical composition, sensory evaluation

INTRODUCTION

Plantain, banana and cooking banana (*Musa* sp. AAA, AAB and ABB groups) are major starchy staples of considerable importance in the tropics. They are consumed both as energy-yielding food and as dessert, providing more than 200 calories (food energy) a day (Stover and Simmonds, 1987). They may also be sold as fresh fruit or for processing, to boost farm income. Total world production of bananas (including cooking bananas and plantains) is approximately 100 million tons. Of this total, about 87% is produced for local and national markets and for home consumption. Millions of farm households in the subtropics and tropics of the world produce bananas in backyard gardens, in mixed field cropping, in association with trees and also in intensive monocrops (http://bananas.bioversityinternational.org/content/view/67/97/lang,fr/(2007).

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Plantains are known to be a great source of calcium, vitamins A, B_1, B_2, B_3, B_6, C and minerals such as potassium and phosphorous. Ripe mashed banana is an excellent food for babies after the six month exclusive breast feeding. This advantage is due to the easy digestibility and the mineral and vitamin content. For elderly people, the fruit can be consumed in large quantities without being fattening or causing digestive disturbances (http://www.turbana.com/index.htm, accessed August 14, 2003).

Plantain is known to be low in sodium (Chandler, 1995). It contains very little fat and no cholesterol; therefore it is useful in managing patients with high blood pressure and heart disease. They are free from substances that give rise to uric acid therefore, they are ideal for patients with gout or arthritis. Due to the low sodium and protein content, plantain is used in special diets for kidney disease sufferers. The capacity of the plantain to neutralize free hydrochloric acid suggests its use in peptic ulcer therapy (http://www.turbana.com/index.htm; Accessed August 14, 2003).

A fully ripe plantain mixed with milk powder is especially recommended for ulcer patients. For patients with gastritis and gastro-enteritis, banana is one of the first foods to be introduced after nausea and vomiting are brought under control. The low lipid/high palatability combination is ideal for the diet of obese people (http://www.turbana.com/index.htm, accessed August 14, 2003). The plantain plant has also some medical properties. The leaves can be pounded and applied to the wound to suppress bleeding.

They are also very important sources of rural income (Ortiz and Vuylsteke, 1996). They are attractive to farmers due to their low labour requirement for production compared to cassava, maize, rice and yam (Marriott and Lancaster, 1983).

In the agricultural sector in Ghana, plantain is ranked fourth and contributes about 13.1% to the Agricultural Gross Domestic Product (AGDP). Its per capita consumption of 101.8 kg (FAO, 2005) is higher than all other starchy staples. It is of great socio-economic and nutritional significance and generates considerable employment.

Despite the high value of plantain and banana, growing pest and disease pressures have affected production, the most notable being the fungal disease Black Sigatoka (*Mycosphaerella fijiensis*) (IITA, 1992; Stover and Simmonds, 1987; Swennen, 1990). Yield losses due to the disease are highly significant ranging from 20 to 50%. Under very severe conditions yield losses may be as high as 80%. Unfortunately all the plantain landraces in Ghana are susceptible to the Black Sigatoka disease. In view of this, new tetraploid hybrids were introduced in 1994 to complement the landraces. These tetraploid hybrids were developed from crosses between diploid and triploid *Musa* species through embryo rescue. They are known to be high yielding and disease tolerant, nevertheless, it is imperative to compare them with the already existing landraces. It was therefore necessary to evaluate the hybrids alongside the landraces. This study was to compare the agronomic, nutritional composition and consumer preference of FHIA-21 (tetraploid hybrid French plantain) to Apem (a triploid French plantain).

MATERIALS AND METHODS

The trials were established in 2002 at two locations namely Fumesua in the Ashanti region and Assin-Foso in the Central region of Ghana during the major rainy season (April-July). The locations were selected on the basis of the variation in the soil types and the severity of black Sigatoka incidence. Fumesua is characterized by sandy-loam (Arenosols) soils. The Assin-Fosu soils are red-brown and clay-rich (Nitrosols). The design was randomized complete block with three replications. No soil amendments were applied. Plant spacing of 3×2 m was used giving a plant population of 1667 plants ha^{-1}. Each plot had fifteen plants per plot. Field maintenance was slashing alternated with glyphosate application. Data was collected on plant height at flowering and at harvest, pseudostem

girth at one metre above ground, number of leaves at flowering and at harvest, number of months to flowering and to harvest, bunch weight, number of hands per bunch and number of fingers. The black Sigatoka disease were assessed using the Stover scale of 1 to 10 (1 as very low and 10 as very severe disease incidence (Stover and Simmonds, 1987) as observed on the 3rd leaf.

Fruits were harvested from the Fumesua and Assin Foso fields for laboratory analysis. Harvesting was done at physiologically matured stages of the fruits and taken to the laboratory for analysis.

Physiochemical Analysis

Moisture, crude fat, ash, crude protein and crude fibre contents were determined using Official Methods of Analysis (AOAC, 1994). All the minerals (i.e., Sodium, Potassium, Iron, Phosphorus and calcium) were determined using atomic absorption spectrophotometer after acid digestion of the sample.

Colour Determination

The pulps were sliced into thin slices of 5 mm thickness and placed on a petri dish. The colour was determined using the Chromameter (Model Cr-200 Minolta Camera Co. Ltd, Japan) on the L*, a* and b* scale colour notation. The sensor of the Chromameter was placed on the sliced pulp and the colour measured at three randomly selected positions and the mean calculated. The Chromameter was calibrated using a standard white tile [L* = 100.01; a* = -0.01; b* = -0.02]. The L coordinate is a measure of lightness (white-black and ranges from no reflection L = 0 to perfect diffuse reflection L = 100), the a scale ranges from negative value for green to positive values for red and the b scale ranges from negative values for blue to positive values for yellow.

Sensory Evaluation

Untrained taste panelists from various category of consumers in Kumasi in the Ashanti region of Ghana comprising both males and females were used in the study. Assessors were not selected or trained to produce a panel showing definite preference but rather one which consistently reflected the range of preferences likely to be typical of Ghanaian consumers. At each time, panelists were presented with two coded samples (A and B) of *fufu* and *ampesi* comprising of Apem and FHIA-21 were asked to compare the two coded samples on the bases of texture, taste, colour and overall acceptability, using the Hedonic descriptive scale of 1-5 (Table 1). In addition, panelists were asked to state which of the two samples they preferred most. All assessors were instructed in basic taste panel procedures: to make their own individual judgments after a moderate amount of consideration (Dadzie, 1997). They were instructed to take a sip of water and pause briefly before tasting each sample and to re-taste if they are not sure of their decisions. Data were analysed using t-test.

The local dishes prepared were: *Ampesi*: Is prepared by boiling the pulp of green fruits: As the firmness of the raw pulp of introduced accessions was low, the fruits were boiled for between 10 and 15 min only whereas the local cultivar, *Apem*, with very firm pulp was boiled for 30 min. The *Ampesi* was offered to the panelist with a vegetable sauce.

Table 1: Hedonic scoring for the assessment of consumer acceptability of unripe plantain

Scale	Texture	Taste	Colour	Flavour	Overall acceptability
1	Too hard	Excellent	Excellent	Excellent	Excellent
2	Very hard	Very acceptable	Like very much	Like very much	Very good
3	Good	Good	Good	Good	Good
4	Fair	Fair	Fair	Fair	Fair
5	Poor	Poor	Poor	Poor	Poor

Fufu: Is prepared by boiling the pulp of green fruits and cassava. In this case, the pulp of the hybrids was boiled for fifteen minutes while the cassava and the pulp of Apem were boiled for 30 min. The cassava and the plantain pulp were pounded into a paste and eaten with soup, fish, chicken and meat. The fufu was offered to the panelists with soup.

Fried Ripe Plantain

The ripe fruits were peeled and sliced transversely of about two centimeter thickness. The slices were dipped into salty water and deep fried in vegetable oil.

RESULTS AND DISCUSSION

At each of the two locations, FHIA-21 exhibited stable performance in yield and growth characteristics over the three years of study and compared favourably with the triploid Apem (Table 2). Also the performance of FHIA-21 in yield and growth characteristics across the locations was consistent and suggested its stability. These results suggested that performance of FHIA-21 and Apem was not influenced by locations. The hybrid was however superior to the landrace in terms of vigour. It implies that under good management practices, farmers would be assured of good yields irrespective of time or season of planting so long as there is adequate supply of moisture.

Comparing the performance of FHIA-21 with the land race Apem pa, FHIA-21 exhibited superiority in growth and yield for the two locations tested (Table 2). FHIA-21 was 21% shorter in height and 8% thicker in pseudostem circumference than the land race suggesting that plants of FHIA-21 were sturdier than the landraces. The results of this study compared with those of Alvarez (1997). It is therefore more likely that FHIA-21 would escape stem lodging. FHIA-21 also retained more functional leaves at flowering than the land landraces; which possibly contributed to the higher yield of FHIA-21 (Table 2). FHIA-21 produced 43% higher yield than the landraces. The number of functional leaves a plantain or banana maintained at flowering determines the yield (Alvarez, 1997).

FHIA-21 showed minimal disease incidence of about 1.1% on the Stover scale at all locations. The highest incidence was observed at Assin-Fosu. This was not surprising as the disease was first observed at the location in Ghana. The reference plantain cultivar showed between 40-70% incidence of the disease. The study has confirmed the report of Dadzie and Orchard (1997) which indicated that FHIA-21 was bred against black Sigatoka and with superior agronomic potential.

The nutritional values of FHIA-21 (hybrid plantain) and Apem (French plantain) plantain were compared (Table 3). Moisture level was appreciably high in FHIA-21 (60%) compared to Apem

Table 2: Comparison of yields and selected agronomic parameters of FHIA 21 with two French plantain landraces at Fumesua and Assin Fosu

	Varieties			
	2002		2003	
Parameters	FHIA 21	Apem Pa	FHIA 21	Apem Pa
Plant height at harvest (cm)	252.3±2.1	352.0±2.7	256.0±2.0	353.0±1.8
Pseudostem girth (cm)	54.7±1.0	59.2±1.8	49.7±1.3	57.5±2.0
No. of daughter suckers	5.3±0.1	4.5±0.2	4.7±0.4	4.0±0.4
No. of leaves at flowering	12.1±0.2	10.0±1.0	13.3±2.0	11.0±1.3
No. of leaves at harvest	7.3±2.1	4.0±1.0	7.0±0.5	4.0±1.0
No. of months to harvest	14.8±1.2	18.0±0.7	15.0±1.2	18.5±1.0
No. of hands bunch^{-1}	7.3±1.1	8.0±1.0	8.0±1.0	8.0±0.5
No. of fingers bunch^{-1}	101.0±1.0	109.0±0.5	100.0±1.2	111.0±0.7
Bunch weight (t ha^{-1})	35.7±3.1	24.0±4.0	36.5±0.8	25.3±3.2
Black Sigatoka incidence (%)	1.2±1.5	3.4±2.4	1.1±1.3	3.6±2.1

Table 3: Nutritional composition of APEM and FHIA 21 (Composition (per 100 g dry weights)

	Varieties	
Parameters	APEM	FHIA 21
Moisture (%)	53.10±0.02	60.62±0.490
Fat (%)	0.22±0.06	1.94±0.550
Ash (%)	1.00±0.03	1.02±0.140
Crude fibre (%)	1.04±0.04	1.02±0.050
Crude protein (%)	2.19±0.05	2.08±0.030
Carbohydrate (%)	42.50±0.05	41.52±0.030
Pulp to Peel ratio	1.23±0.04	1.36±0.060
Potassium (mg)	760.00±0.02	1060.00±0.002
Calcium (mg)	13.20±0.02	11.20±0.010
Iron (mg)	1.06±0.03	0.45±0.050
Sodium (mg)	45.30±0.04	49.50±0.020

(53.1%). This could be attributed to the banana characteristic in the FHIA 21 hybrid. This shows that Apem had higher dry matter than the tetraploid. The low water content in plantain is reported to have an influence on general energy and nutrient density (Gowen, 1995). The low water content has greater energy content. The value observed for the high pulp to peel ratio in the hybrid was below the range reported by Dadzie (1997) (Table 3). In a similar study on FHIA-21, FHIA-22 and Cuerno, cultivars, pulp to peel ratios of 1.30-1.6, 1.40-1.70 and 1.50-1.70 ranges, respectively were observed (Dadzie, 1997). However, in this study, the results showed a lower value for the hybrid. This could predispose the fruits to mechanical damage. Their transportation over long distances would require care especially in Ghana where the roads are not very good.

Fat content was higher in the hybrid (1.94%) compared to Apem (local cultivar) 0.22%. This could be an added advantage of the hybrid over the local Apem. There was no difference in the ash contents of FHIA-21 and Apem. The ash contents were 1.02 and 1.0%, respectively. Iron level was lower in the hybrid compared to the local plantain. However, potassium was higher in the hybrid plantain and lowest in the local Apem. It is reported that plantains are rich in vitamin B_6 and the combination of the vitamin B_6 and potassium makes it nature's brain food, since these two substances are essential for proper brain function (http://www.turbana.com/index.htm, Accessed August 14, 2003). The sodium levels are low while potassium levels are high; however, the high potassium provides a protective effect against excessive sodium intake (Meneely and Batterbee, 1976). The high potassium level in the hybrid may be an added advantage of the hybrid over the local for use as a therapy. As regards iron, plantain is poor source (0.5 mg/100 g) however, unlike other foods; the iron provided by plantain is 100% utilizable by human body.

Calcium and phosphorous on the other hand are vital for bone. The calcium contain was slightly higher in Apem compared to FHIA 21. The soft nature of the hybrid makes it easy to cook and for mastication when prepared as slice compared to the local (Dzomeku *et al*., 2004).

The results of the study showed that the nutritional composition of the hybrid related very well with the findings of Chandler (1995). FHIA-21 could be described as a high energy yielding carbohydrate compared to Apem. The fat content of the hybrid was higher than that of the local Apem signifying higher calorific value. The nutritional composition of the hybrid matches that of the local. The hybrid could be recommended as a good starchy staple for consumers of plantain.

The peel and pulp colour of the plantain were assessed as they serve as major criteria used by consumers, growers and research workers to determine whether a fruit is ripe or unripe. In Ghana, most consumers tend to associate the colour of the pulp to maturity. If the colour of the pulp of plantains were orange/yellow or light orange then the fruit was matured, if on the other hand it was white it indicates that the fruit was immature. In general the cultivar studied had green peel colour (at matured unripe stage) as indicated by the L, a, b values (Table 4). Like plantains the pulp colour of FHIA-21 was light or bright orange comparable to the pulp colour of triploid French

Table 4: Peel and pulp colour of FHIA-21 (hybrid) and Apem (local French plantain

	Varieties	
Colour	APEM	FHIA-21
Peel		
L	54.30±0.21	63.90±0.15
a*	- 8.40±0.15	-17.40±0.16
b*	38.20±0.27	35.60±0.24
Pulp		
L	103.70±0.06	100.36±0.21
a*	0.09±0.00	0.11±0.00
b*	23.00±0.03	27.00±0.01

Table 5: Comparative sensory evaluation of selected hybrids evaluated for *ampesi* at four locations in the Assin districts

Hybrid/cultivars	Texture	Taste	Flavour	Colour	Overall acceptance
Ampesi					
FHIA-21	4.32a	4.56a	4.48a	4.54a	4.54
Apem	4.32a	4.56a	4.48a	4.86a	4.89
Fried ripe plantain					
FHIA-21	4.12a	4.71a	4.26a	4.45a	4.71a
Apem	4.62a	4.78a	4.78a	4.67a	4.78a
Fufu					
FHIA-21	4.24a	4.24a	4.24a	4.24a	4.67a
Apem	4.24a	4.24a	4.32a	4.24a	4.67a

Letter s in common within columns were not significantly different at the 1% level

plantain (Table 4). The orange colour of the pulp is an indicative of the rich provitamins and carotenoids (Gowen, 1995). The results for the peel and pulp colours of the cultivars studied were similar to the results of (Dadzie, 1993). There was no difference between the peel and pulp colour of the hybrids and the landrace.

There was no significant difference between *ampesi* (boiled green sliced plantain) of FHIA 21 and the *Apem*. (local French plantain) in terms of tasted, texture, flavour and colour. The triploid French plantain when boiled green is crunchy whereas the tetraploids become slightly soft when boiled green. It is significant to mention that, cooked samples of FHIA-21 tasted similar to Apem. The attractive pulp colour of cooked FHIA-21 was similar to that of Apem. It came to light that the hybrid does not boil for long before cooked. Work by other researchers indicated that loss of firmness or softness in fruits as a result of cooking or heating, involves the loss of turgor, a series of chemical changes in the cell matrix polysaccharides and the swelling and gelatinization of starch (Van Buren and Pitifer, 1992).

The hybrid was accepted when processed into ripe fried at ripening stages 3 and 4. FHIA-21 was highly preferred (Table 5). Taste was a key characteristic that determined the acceptability of the hybrid. The results compared favourably with a similar study by Dzomeku *et al*. (2006) and Dadzie (1998).

In Ghana just as it is in most countries in West and Central Africa where green plantains are consumed as a major part of the meal, the predominant method of cooking matured green unripe plantains include, boiling or steaming and served as a cooked vegetable with stew or sauce. Sometimes, the green plantain is roasted or baked and frequently the green plantain is also pounded after cooking into a paste or dough, often in combination with cassava (called *fufu*) and served with soups, sauces and meat or fish. Because of the varying methods of cooking and uses of plantains, the texture, particularly, the softness of the cooked plantain is very important in determining a good cooking plantain cultivar. The choice of a plantain cultivar for particular method of cooking or processing is therefore probably based largely on the textural properties of the tissues after cooking. Consumers often prefer plantain cultivars that have good textural qualities after cooking and should suit the various uses.

CONCLUSION

The study has revealed that FHIA-21 was high energy yielding carbohydrate compared to Apem. These results suggested that performance of FHIA-21 and Apem was not influenced by locations. It implies that under good management practices, farmers would be assured of good yields irrespective of time or season of planting so long as there is adequate supply of moisture. The fat content of the hybrid was higher than that of the local Apem signifying higher calorific value. The nutritional composition of the hybrid matches that of the local. However the hybrid was softer than Apem. This could be attributed to the genetic make-up of the hybrid, which is a cross between plantain and banana. FHIA-21 compared favourably with Apem for *fufu*, *ampesi* and fried ripe plantain.

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