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Determination of Micronutrients and Colour Variability among New Plantain and Banana Hybrids Flour

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Abstract: Quantitative colour variability and micronutrient content of new plantain and banana hybrids flour was investigated. The mean flour colour of the cultivars ranges from 12.16 for BITA 3 to 18.52 for FHIA 23, which is an indication of varying degree of yellowness. Both FHIA 23 and PITA 17 had colour value higher than the general sample means. Agbagba contained the highest level of iron (36.5 µg g^{-1}), which is higher than the overall sample means, followed by FHIA 17 (16.135 µg g^{-1}). The rest of the cultivars, including FHIA 17 contained iron levels lower than the sample means. Similarly, Agbagba had the highest level (12.5 µg g^{-1}) of zinc, followed by FHIA 17 (12.49 µg g^{-1}). The value of zinc obtained in Agbagba, FHIA 17 and BITA 3 were higher than the general sample means. The total carotenoid contents of the cultivars are similar, with PITA 17 (4.795 µg g^{-1}), FHIA 17 (4.15 µg g^{-1}) and PITA 14 (3.815 µg g^{-1}) having values higher than the overall sample means. The estimated retinol equivalent of the flours ranges from 0.43 in FHIA 23 to 0.799 in PITA 17. The new *Musa* hybrids may be acceptable for increased production based on disease resistant, high yield and micronutrient content.

Key words: Disease resistant · hybrids · colour · micronutrient · flour

INTRODUCTION

Plantain and banana (*Musa* spp.) are major food crops in the humid and sub-humid parts of Africa and a major source of energy for millions of people in these regions [1]. The annual world production of plantain and banana is estimated at 75 million tones [2]. In Nigeria, plantain production is estimated at about 2.11 million metric tonnes in 2004 [3]. The development and dissemination of disease resistant, high yielding varieties of plantain and banana by various research institutes had evolved over the years, which has hitherto led to increase in production. Thirteen new varieties of plantain and banana hybrids developed by the International Institute of tropical Agriculture (IITA) were massively disseminated to the farmers in Nigeria and many parts of West and Central Africa (WCA) and East and Southern Africa (ESA). This is part of IITA's intervention to increase agricultural productivity, income and well being of poor resource farmers and generate raw materials for industries. Five of these cultivars were selected in eleven states based on farmers' perception, including two IITA plantain hybrids (PITA 14 and PITA 17), two FHIA banana hybrids (FHIA 17 and FHIA 23) and one IITA cooking banana hybrid (BITA 3).

Worldwide, vitamin A deficiency is the most common form of malnutrition after protein deficiency [4]. In parts of Asia, Africa and Latin America, vitamin A deficiency occurs in millions of children [5] and plantain and banana could be an important source of provitamin A for the people of those regions. In Nigeria, 50% of children and 61% of women in the Southeast suffer from chronic anaemia, due to iron deficiency [6], whose symptoms includes learning disability, mental retardation, poor physical development and reduced ability to fight infectious diseases, ultimately leading to premature death. Zinc deficiency has been implicated in growth failure, hypogonadism and anaemia [7]. Research has been directed to combat micronutrient deficiency through nutritional breeding by various institutes. This has recently been achieved in rice and canola through genetic manipulation [8]. Intervention studies undertaken

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using ß-carotene supplements rather than using foods with enhanced carotenoid levels resulted in no potential benefit. Also, food supplements and fortified products are beyond the reach of many households in the developing countries. This therefore provides as strong stimulus to investigate the pro-vitamin A component of the new plantain and banana hybrids generated by IITA, in furtherance of micronutrient initiative of the CGIAR (Consultative Group on International Agricultural Research).

Carotenoids are one of the most important classes of plant pigments and play a crucial role in defining the quality parameters of fruit and vegetables [9, 10]. The red capsanthin, capsorubin and cryptocapsin pigments are valued mostly as natural colorants, whereas β-carotene, α-carotene, γ-carotene and β-cryptoxanthin have provitamin A activity, with β-carotene having the highest [11]. During ripening the colour of plantain and banana changes from dark green to bright yellow, due to the degradation of chlorophyll structure. This process gradually unmasks the carotenoid pigments present in the fruit [12]. Change in peel colour often reflects changes in pulp colour [13, 14]. In Ghana, Nigeria and Honduras, consumers have developed distinct correlations between colour and the overall quality of specific products [10]. Consumers of plantain and banana associate colour of the peel with specific tastes or uses and they will usually purchase plantain or banana if the colour is suited to the required purpose or desire. Information on the total carotenoids, iron and zinc, and flour (not pulp) colour variability of plantain and banana, especially, the newly developed hybrids are very fragmentary. This study was therefore articulated to determine the micronutrient component and colour variability of new plantain and banana hybrids as an important step to enhance nutritional breeding.

MATERIALS AND METHODS

The five leading cultivars of plantain and banana hybrids in Nigeria (PITA 14, PITA 17, BITA 3, FHIA 17 and FHIA 23), including the check, Agbagba were investigated. Samples were obtained from the experimental station of the International Institute of Tropical Agriculture (IITA), High Rainfall Station, Onne agro ecology, located on Latitude 04° 43'N, Longitude 07° 01'E and 10 m Altitude, near Port Harcourt, Nigeria.

Determination of flour colour and micronutrient content: The colour of plantain and banana flours was quantitatively determined with the aid of a hand-held ColourTec PCM/PSM^{TM1} colour meter. Three fruits were collected from the second hand from the proximal end of the bunch following the recommendation of Baiyeri and Ortiz [15] the same day the bunch was harvested. The fruit samples were washed in a plastic bowl with potable water to remove dirt and peeled manually with the aid of stainless kitchen knife. The pulps were sliced longitudinally to about 15 mm thick and dried in Forced-Air Sanyo Gallenkamp Moisture Extraction Oven at 65°C for about 48 h and milled with the aid of stainless Kenwood Chef Warring Blender, Model KM001 (0067078) series. About 35 g aliquot flour was placed in a petri dish. The nosecone and sensor of the colour meter was placed at the middle of the flour and pressed down firmly and flatly against the surface of the sample before and during the measurement to prevent external light.The Green DO Key was depressed to start a measurement process, which lasted for five seconds and generated a set of numbers when the measurement was completed and this represent the reflectance of the sample viewed by the sensor. The displayed measurement result is a specific calculation made using the sample reflectance. The data obtained was displayed on the Liquid Crystal Display of the colour meter. The corresponding figure was compared to Colour-Tec^{TM} CIE LAB Colour Chart and the degree of yellowness read off. Three different samples from each cultivar were examined and the readings averaged to obtain the means. Total carotenoid content of the pulp and flour was performed spectrophotometrically using the method described by Rodriguez-Amaya [16]. Iron and zinc analysis in the flour were determined using A.O.A.C. [17] procedures. All chemical analysis was performed at the International Institute of Tropical Agriculture (IITA) and all the chemicals used were of analytical grade.

RESULTS AND DISCUSSION

Tables 1 and 2 present the quantitative colour variability, micronutrient content and contribution of plantain and banana flour to meeting daily vitamin A requirements of individuals.The mean flour colour of the new hybrids ranges from 12.16 for BITA 3 to 18.52 for FHIA 23. This indicates that new plantain and banana had varying degrees of yellowness. Among the varieties, FHIA 23 and PITA 17 had colour variables higher than the sample means. This variation implies genotypes differences in pigment composition or pulp browning potential [18]. Agbagba had the highest iron content (36.5 μg g^{-1}) followed by FHIA 17 (16.135 μg g^{-1}). These values are higher than 1.06 mg/100 g obtained in raw

Table 1: Micronutrient content (µg g^{-1}) and mean flour colour (B) variability among a selection of new plantain and banana hybrids

Cultiver	Colour	Iron	Zine	Total Carotenoids
PITA14	1.266	14.275	5.670	3.815
PITA 17	1.642	15.275	5.080	4.795
BITA 3	1.216	15.515	8.820	3.220
FHIA 17	1.379	16.135	12.490	4.150
FHIA 23	1.852	14.270	6.750	2.580
AGBAGBA	1.427	36.500	12.500	3.040
Mean	14.600	18.660	8.550	3.600
SE	0.990	3.580	1.350	0.330

B = represents the degree of yellowness on the CIE LAB Colour Chart

Table 2: Comparison of new plantain and banana hybrid flour for their contribution to meeting daily vitimin A requirements: 50 Retinol Equivalents (RE) for non-pregnant, non-lactating females 19-65 years; 400 RE for children 1-3 years [33]

Cultivar	TC (µg g^{-1})	$(RE)^e$	$(RE)^e$ if 500 g is eaten daily	$(RE)^e$ if 1000 g is eaten daily
PITA 14	3.815	0.636	317.9	635.8
PITA 17	4.795	0.799	399.6	799.2
BITA 3	3.220	0.537	268.3	536.6
FHIA 17	4.150	0.692	345.8	691.7
FHIA 23	2.580	0.430	215.0	430.0
AGBAGBA	3.040	0.507	253.3	506.7

TC=Total Carotenoids; $(RE)^e$ =Retinol Equivalent

green plantain [19]. Interestingly, new plantain and banana hybrids contribute much higher levels of iron in human diet compared to 0.2-0.3 mg/100 g values obtained in flours of two sweet potato varieties [22]. Loeseck [21] reported that the iron content of plantain is 100% utilisable for human consumption unlike other foods. Agbagba also contained the highest level of zinc (12.5 µg g^{-1}) followed by FHIA 17 (12.49 µg g^{-1}) compared to the rest of the cultivars evaluated. This is much higher than 0.26 mg/100 g obtained by Ahenkora *et al*. [19] in *Apantu pa* plantain landrace in Ghana. Increased consumption of new plantain and banana may contribute to offset micronutrient deficiencies. PITA 17 had the highest total carotenoid content (4.795 µg g^{-1}) while FHIA 23 had the lowest (2.58 µg g^{-1}), with PITA 17, FHIA 17 and PITA 14 having values higher than the sample means. The vitamin A content of Cavendish banana is 60 µg of retinol equivalent/kg [22], which is apparently much lower than those obtained in the new hybrids (Table 2). The average carotene content obtained by Asenjo and Porrata [23] was 10.46 µg g^{-1} and 6.68 µg g^{-1} in green and ripe plantain, respectively. The results obtained for total carotenoids in the new hybrids is about half of these previous data, which demand for improvement in nutritional breeding. The levels of carotenoids vary between plantain varieties within a 10-fold range; the orange pulp fruit being the richest [22]. Contrarily, lowest levels of β-carotene and total carotenoids have been reported in fresh *Capsicum* fruit [11], which is in consonance with the report for bell peppers, in which β-carotene was highest in brown and red fruit and lowest in orange- and yellow-fruited cultivars [24]. In this present study, the carotenoid content was not influenced by the degree of yellowness in flour colour (Table 1). Wall *et al*. [11] reported a wide variation of total carotenoid (4.0-1173 µg g^{-1} FW) in *Capsicum annuum*. It has been reported that individuals with low carotenoid intake and/or low carotenoid blood levels have an increased risk of degenerative diseases [25]. Strong evidences [26, 27] also exist for a reduced cancer risk in individuals with high intakes of carotenoid-rich fruits and vegetables or high carotenoid blood levels. Knekt *et al*. [28] reported an increase in cataract risk in patients with low plasma β-carotene levels. The antioxidant properties of carotenoids appear to protect against heart disease [29] and cancer of the lungs, stomach, cervix and throat [26, 30]. Epidemiological research suggests that carotenoid-rich foods protect against certain chronic diseases, including diabetes, heart disease and cancer [31, 32]. Of the six cultivars analysed in this present research, 5 contained enough pro-vitamin A carotenoids to meet at least half of the estimated vitamin A requirements for a non-pregnant, non-lactating woman if 500 g of flour is eaten daily, based on FAO/WHO [33] Recommended Daily Dietary Allowances. For children between 1-3 years, PITA 17 and FHIA 17 may contribute about half of their vitamin A requirement if 250g of the flour is eaten daily. Plantain and banana flour may be reconstituted in boiling water to make "amala" and eaten with vegetable soup. It is also used for several other traditional dishes ranging from "akara", moin-moin, fritters and soup. Plantain and banana flour is currently being exploited in baking and complementary weaning foods in Nigeria [32, 34, 36]. Traditionally made plantain and banana flour is sold in several cities in Nigeria, which is a strong indication that farmers and plantain processors are beginning to adopt plantain flour, which is a means of reducing post harvest losses.

CONCLUSIONS

The International Institute of Tropical Agriculture has developed several disease resistant and high yielding

*Mus*a hybrids, which produces two to five times more than traditional landraces, under natural conditions with no chemical control of black Sigatoka disease. Quantitative colour variability and total micronutrient content of flour from a selection of new *Musa* hybrids flour was investigated. This present data may probably help to identify local micronutrient-rich foods that can be promoted to alleviate Vitamin A Deficiency (VAD) and other micronutrient related diseases. Plantain consumers will benefit in the long run due to anticipated reduction in regional food insecurity, whilst increasing their micronutrient status and greater investment in productive enterprises through value added products.

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