

EFFECT OF PROCESSING AND STORAGE ON THE COLOUR OF PLANTAIN AND BANANA PRODUCTS

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ABSTRACT

Fresh pulp from freshly harvested plantain and chips colour as well as the effect of processing and storage on the colour of plantain and banana hybrids flour were investigated. Colour values L^ (degree of lightness), a^* (degree of redness) and b^* (degree of yellowness) were determined with focus on b^* value, which is relevant to the pulp colour in African plantain landraces. Agbagba (38.10) and PITA 17 (37.78) differed significantly ($P < 0.05$) from other cultivars in fresh pulp degree of yellowness, b^* . The degree of yellowness in plantain chips showed that Agbagba (55.03) differed significantly ($P < 0.05$) from all the hybrids. Colour degradation was observed in Musa flour during storage. PITA 14 flour stored in the illuminated experimental cupboard was significantly higher ($P < 0.05$) compared to flour from other cultivars in the degree of yellowness (16.91) after 90 days of storage. Similarly, flour made from PITA 14, stored in dark compartment, with a mean yellowness of 18.35, after 90 days of storage was significantly different ($P < 0.05$) from other cultivars. Established storage condition is critical to plantain and banana production and their diversified value added products.*

Key words: Hybrids, processing, storage, yellowness, colour degradation.

INTRODUCTION

Plantain (*Musa* AAB), cooking bananas (*Musa* AAB, ABB), bananas of West Africa origin (*Musa* AAA) and dessert bananas (*Musa* AAA) belonging to the family *Musaceae* constitute one of the major agricultural produce and consequently one of the major staple foods in producer countries. The annual world production of plantain and banana is estimated at 75 million tonnes (John and Marchal, 1995). In Nigeria, plantain production is estimated at about 2.11 million metric tonnes in 2004 (FAO, 2005). Traditionally bananas are usually eaten raw as dessert while plantain and cooking bananas on the other hand are traditionally grown for cooking as part of a staple diet, or for processing into more durable products such as flour that can be stored for later use (Dadzie, 1995; Wainwright and Burdon, 1991). In Ghana, green plantain fruit is sliced into chips, which can be fried in oil or dried and processed into flour. The International Institute of Tropical Agriculture (IITA) has developed and disseminated several cultivars of improved plantain and banana hybrids to farmers in West and Central Africa (WCA) and East and Southern Africa (ESA), an intervention programme aimed at improving the livelihood of

poor resource farmers and generating raw materials for industries.

Post harvest loss is a major problem limiting the production of plantain and banana in Africa due to unavailability of established storage conditions that can guarantee longer shelf life (Wills, *et al.*, 1989). Investigations on the use of different grades of polyethylene bags for extending the green life of plantain fruits have been carried out (Wills, *et al.*, 1989). During ripening the colour of plantain and banana changes from dark green to bright yellow, due to the degradation of chlorophyll structure, which gradually unmasks the carotenoid pigments present in the fruit (Robinson, 1996). Change in peel colour often reflects changes in pulp colour (Wainwright and Hughes, 1989). In Ghana, Nigeria and Honduras, consumers have developed distinct correlations between colour and the overall quality of specific products (Dadzie and Orchard, 1997). 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. For example, plantain chips are conventionally produced by deep-frying of green (unripe) slices

in oil, an important method of processing the fruit to ensure a longer shelf life (Ogazi, 1996). The shelf life of plantain chips is greatly reduced when exposed to light and air. Therefore, chips must be packed in moisture proof bags to prevent absorption and loss of crispness (Stover and Simmonds, 1987). Ogazi (1996) reported that chips packaged in polyethylene bags become rancid with time, due to the reaction of oxygen from air with fat in the oil. Rancidity is manifested in colour change and taste. The typical golden yellow colour of plantain chips fades away gradually, and turn to light colour (Ogazi, 1985). The use of cellophane is recommended for packaging to increase the shelf life of plantain chips. Cellophane is non-permeable to water, water vapour and air, while polyethylene is permeable to air (Ogazi, 1996). This study was therefore articulated to investigate if genetic differences exist in different fresh *Musa* pulp colour and their products during storage. This is an important step to provide relevant data on fruit qualities, utilisation and storage potentials.

MATERIALS AND METHODS

PLANT MATERIALS.

Five new cultivars of new plantain and banana hybrids developed by the International Institute of Tropical Agriculture (IITA) and released into the farming systems in West and Central Africa (WCA) and East and Southern Africa (ESA) were investigated, including the preferred landrace, Agbagba. These included four plantain hybrids (PITA 14, PITA 17, PITA 24, PITA 26) and a cooking banana hybrid (BITA 3). These hybrids were chosen based on their consistent agronomic performance, post harvest qualities and farmers' perception. 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 10m Altitude, near Port Harcourt, Nigeria. The soil is sandy loam Oxisol of Nkpologu series (Ndubizu, 1981). Rainfall is bimodal with an annual total of about 1500mm.

Preparation of flour.

Finger samples were collected from the second hand from the proximal end of the bunch following the recommendation of Baiyeri and Ortiz (2000) the same day the bunch was harvested. Samples were hand peeled and immersed in a plastic bowl containing potable water to prevent browning, and then sliced longitudinally into two with the aid of stainless kitchen knife. Sliced pulps were dried in Forced-Air Moisture Extraction Plus II Oven, Sanyo

Gallenkamp PLC, United Kingdom, at 65°C for about 48 hours and milled with the aid of stainless Kenwood Chef Warring Blender, Model KM001 (0067078) series.

Preparation of chips.

Deep-fried chips (crisps) were prepared according to the procedures described by Adeniji (2005) and Yomeni et al. (2004). Bunches were harvested at green stage and de-handled prior to de-fingering of representative fingers from the second hand from the proximal end of the bunch following Baiyeri and Ortiz (2000) recommendation. Fruits were washed to remove dirt and latex and then carefully hand peeled with the aid of stainless kitchen knife and the resultant pulps were immersed in water until the peeling is completed to prevent browning. Pulps were removed into a clean bowl and seasoned with salt. The salted fruits were sliced disc-wise directly into a pre-heated vegetable oil in an electric fryer, Lincat Model LDF, series 9418072, Lincat Ltd., Lincoln, England at 190°C. Slicing was done with the aid of Plantain Slicer, SF923-1, CEE Square Ltd., Leewood Blvd, Houston, Texas, USA. Slices were stirred constantly during frying until crisp bright yellow (in case of plantain) or cream to pale yellow (in case of banana) chips was obtained. Chips were scooped into an aluminium plastic sieve and properly drained to remove excess oil, and then spread on polyethylene bag and allowed to cool at room temperature before packing into a heat-sealed polyethylene bag.

Instrumental (quantitative) determination of colour.

Fresh pulp and fried chips colour were determined quantitatively with the aid of a hand-held ColorTec-PCM/PSMTM meter, manufactured by Color-Tec. Clinton, NJ 08809, USA. The colour meter was first calibrated, and this process was repeated each time the instrument was used based on manufacturers guidelines. Three fruits were collected from the second hand from the proximal end of the bunch following the recommendation of Baiyeri and Ortiz (2000) the same day the bunch was harvested. Individual finger was cut transversely to about 2cm thickness from the middle of each fruit with the aid of stainless steel knife. The readings were taken immediately to prevent browning of the cut surface of the fruit, which could affect the readings. The sensor was placed firmly and flatly against the surface of the sample before and during the measurement. 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 represents the reflectance of the sample viewed by the sensor. The displayed measurement result is a specific calculation made using the sample reflectance. The colour of the sample was described by the lightness (*L*), redness (*a*), and yellowness (*b*), the latter, being the most important in this case as it provides information on the degree of yellowness equivalent to plantain colour. The data obtained was displayed on the Liquid Crystal Display of the colour meter. The corresponding figure was compared to Colour-Tec™ CIE LAB Colour Chart for the degree of yellowness. Chips samples were milled with the aid of stainless Kenwood Chef Warring Blender, Model KM001 (0067078) series. An aliquot (35g) was then measured into a petri dish. The nosecone and sensor was placed at the middle of the sample and pressed down to prevent external light. The same procedure used for the pulps was also applied. Three different samples from each cultivar were examined and the readings averaged to obtain the means. The back foot of the colour meter was placed on the table to provide a flat surface with a consistent backing colour that helped to avoid measurement errors.

Determination of flour shelf life

An aliquot, 2kg flour was measured into a transparent polyethylene bag and sealed with the aid of an impulse electric sealing machine, Model ME-300H, Mercieux Corporation, Taiwan. The flours were stored in a two compartment experimental wooden cupboard (Length=100.3cm; Breadth=34.9cm; Height=66cm), made of dark and lighted compartments. A fluorescent tube of 18W/33 was fixed into the upper compartment, while light was completely excluded from the lower compartment. The samples were stored both in the lighted and dark compartments. The temperatures inside the lighted and dark box were 35°C and 28°C, respectively. Colour change was determined after 5, 10, 15, 74 and 90 days with the aid of a hand-held ColourTec PCM/PSM™ meter.

Statistical Analysis.

The data generated were analysed using Statistical Analysis Systems version 9.1 SAS (2003) software package. Significance of treatment means was tested at 5% probability level using Duncan's New Multiple Range Test (DNMRT).

Table 1. Colour variability among fresh pulps and chips made from a selection of black Sigatoka resistant *Musa* hybrids.

Cultivar	Fresh pulp colour			Chips colour		
	L*	A*	b*	L*	A*	B*
PITA 14	82.11 ^b	2.84 ^c	32.58 ^b	71.25 ^a	0.00 ^e	49.32 ^b
PITA 17	81.91 ^b	4.05 ^b	37.78 ^a	55.75 ^d	3.42 ^b	45.59 ^c
PITA 24	85.29 ^a	-0.22 ^d	31.72 ^b	66.21 ^b	4.82 ^a	47.97 ^b
PITA 26	77.78 ^c	-2.23 ^e	29.19 ^c	62.34 ^c	2.33 ^c	36.93 ^d
BITA 3	84.85 ^a	0.32 ^d	29.06 ^c	54.75 ^d	3.08 ^b	36.95 ^d
AGBAGBA	80.41 ^b	9.85 ^a	38.10 ^a	70.11 ^a	0.91 ^d	55.03 ^a

Colour values is described by L*=lightness, a*=redness, and b*=yellowness on the CIE LAB Colour Chart (CIE=International Commission on Illumination).

Values in the same column with different letters are significantly different at p<0.05.

Table 2. Effect of storage on flour made from a selection of black Sigatoka resistant *Musa* hybrids

Cultivar	B* values over storage period (days)									
	Light compartment					Dark compartment				
	5	10	15	74	90	5	10	15	74	90
PITA 4	19.15 ^a	18.43 ^a	17.88 ^a	17.23 ^a	16.91 ^a	19.01 ^a	19.06 ^a	18.76 ^a	18.17 ^a	18.35 ^a
PITA 17	18.63 ^b	17.51 ^b	16.89 ^b	15.32 ^b	15.52 ^b	18.21 ^b	18.02 ^b	17.88 ^b	16.12 ^b	16.43 ^b
PITA 24	15.95 ^d	14.70 ^e	13.90 ^e	12.76 ^d	12.60 ^e	16.75 ^c	16.20 ^c	15.52 ^c	13.32 ^d	13.40 ^f
PITA 26	15.53 ^d	15.75 ^d	15.26 ^d	14.30 ^c	14.62 ^c	15.69 ^d	15.68 ^d	15.43 ^c	14.38 ^c	14.97 ^d
BITA 3	15.04 ^e	14.91 ^e	14.24 ^e	13.86 ^c	13.54 ^d	15.15 ^e	15.09 ^e	14.85 ^d	14.03 ^c	13.93 ^e
AGBAGBA	17.84 ^c	16.70 ^c	15.97 ^c	14.29 ^c	13.49 ^d	18.47 ^b	18.33 ^b	17.71 ^b	15.79 ^b	15.27 ^c

Colour values is described by b*=yellowness on the CIE LAB Colour Chart (CIE=International Commission on Illumination). Light compartment=Upper part of the storage cupboard where fluorescent tube was fixed to provide illumination, Dark compartment=Lower part of the storage cupboard without light.

Values in the same column with different letters are significantly different at p<0.05.

RESULTS AND DISCUSSION

Colour variability in pulp and chips samples.

Colour variations were observed among different cultivars of plantain and banana products (Table 1) which implies that genotypic differences exist in pigment composition or pulp browning potential (Tourjee *et al.*, 1998). A combination of colour index, including, L* (degree of lightness), a* (degree of redness) and b* (degree of yellowness) were determined. Results show that L* value for both PITA 24 (85.29) and BITA 3 (84.85) pulps differed significantly ($P < 0.05$) from other cultivars, while African plantain landrace, Agbagba differed significantly ($P < 0.05$) in a* value (9.85) compared to other cultivars. Agbagba (38.10) and PITA 17 (37.78) differed significantly ($P < 0.05$) from other cultivars in fresh pulp degree of yellowness. For the chips, PITA 14 and Agbagba differed significantly ($P < 0.05$) from other cultivars having a lightness value of 71.25 and 70.11, respectively. Chips from PITA 24 had the highest degree of redness with a value of 4.82, which differed significantly ($P < 0.05$) from other cultivars. In terms of chips yellowness, however, Agbagba (55.03) differed significantly ($P < 0.05$) from all the hybrids. This data is consistent with the report of Adeniji (2005) on plantain and banana storage potentials.

Degradative effect of light on flour colour during storage.

A reduction in flour colour index was observed among different *Musa* hybrids during storage. PITA 14 flour stored in the illuminated experimental cupboard differed significantly ($P < 0.05$) from other cultivars in the degree of yellowness (16.91) after 90 days of storage (Table 2). Similarly, flour made from PITA 14, stored in dark compartment, with a mean yellowness of 18.35, after 90 days of storage, was significantly different ($P < 0.05$) from other cultivars. The level of reduction in PITA 14 flour colour was more pronounced in the samples stored in the light compartment, demonstrating the degradative effect of light on the samples.

CONCLUSION

Genetic differences exist among various cultivars of new plantain and banana and their processed products. The colour of plantain and banana flour and chips are prone to degradation during storage, especially when they are exposed to light source. Appropriate packaging materials and storage medium is therefore required to preserve the colour of plantain and banana during distribution and storage. New plantain

and banana hybrids may constitute important raw materials for industrial processing.

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