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HANDLING AND RIPENING CHARACTERISTICS OF HYBRID PLANTAINS COMPARED TO THE LANDRACES AND COOKING BANANA

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ABSTRACT

A study was conducted to determine the rate of respiration and ripening (postharvest characteristics) of different varieties of *Musa* fruit at the International Institute of Tropical Agriculture (IITA), Onne Station, Nigeria. The frequency at which each variety passed from one stage of ripening to the next, and their resistance to harvesting and loading stresses were investigated to ascertain adequacy of the IITA species for the Nigerian postharvest market system. The varieties examined included local plantains (Agbagba and Obino l 'Ewai), hybrid plantains (TMPx548-4 and TMPx 548-9) and cooking bananas (Cardaba and Bluggoe). Result showed that hybrid plantains had the longest (p=0.05) usability-life of 22 days compared to the local plantains (15days) and cooking bananas (13days). The hybrids also exhibited lowest (171 $mgCO_2^{-1}kgh^{-1}$) rate of respiration at the climacteric peak. Highest (p=0.05) resistance to harvesting and loading stresses was exhibited by the local plantains. Fastest frequency of ripening occurred in cooking banana, which had 1.5days between ripening stages 4 (50%green: 50% yellow) and 7 (100% yellow), while hybrid plantains had the slowest (4.0 days). Ripening stage 4 is considered as the *"critical stage"* in the transitional life of *Musa* fruit. Hybrid plantains, "as is" may not fit well into the prevailing postharvest distribution system in Nigeria.

Key word: *Musa fruit, postharvest, respiration, ripening, hybrid plantains, cooking banana.*

INTRODUCTION

Musa (plantain and banana) fruits are integral parts of the humid tropical farming system. It is believed that these crops were some of the first to be domesticated, as they required no specialized tools for harvesting Or propagation (Nweke et al. 1988). The many forms in which they are consumed also indicate the long association between man and these crops. *Musa* fruit is probably the only fruit that can be consumed in unripe, ripe and over-ripe forms. In Sub-Saharan Africa, plantain and banana provide up to 25% of the required food energy (Swennen, 1990). They are also important sources of revenue for backyard producers and large-scale farmers (Nweke, et al. 1988). The International Network for the Improvement of Banana and Plantain (INIBAP) has outlined the major problems limiting the expansion of plantain production in West and Central Africa. High postharvest loss is considered to be a prominent factor (INIBAP, 1988). Most of this loss is caused by inadequate postharvest handling and storage practices. Losses are exacerbated by carrying loads of mixed fruit at different stages of ripeness (mixed fruit ripeness), inefficient packaging systems, insufficient transport vehicles and rough roads, which subject fruit to both static and dynamic stress (Olorunda and Adelusola, 1992). However, susceptibility of *Musa* fruit to physical injury is also influenced by factors such as cultivar (Chukwu, 1997), physiological maturity at harvest, temperature at harvest and handling practices (Seymour et al. 1990).

Environmental factors such as temperature, relative humidity and air composition also affect the potential storage life of harvested fruit (Lentz et al. 1971; Marriott et al. 1979). Another factor that affects the usability of *Musa* fruit is the inherent short green life of the fruit, since ripening ushers in the end of fruit usefulness. Ripening is triggered by increased respiration, which in turn is initiated by ethylene production (Yang and Hoffman, 1984).

We believe that control of postharvest losses is cheaper and perhaps less risky than increasing production to offset losses. Hence screening *Musa* germplasm for variability in physical strength, and breeding for cultivars with longer ripening period and injury resistance offer a possible solution. This research is aimed at examining the resistance of different varieties of *Musa* fruit to postharvest harvesting and loading stresses, and to determine their rate of respiration and ripening as measures of fruit usability index. The information generated will serve as a guide for selecting appropriate variety in the breeding program.

MATERIALS AND METHODS

Experiments were carried out at the International Institute of Tropical Agriculture (IITA), High Rainfall Station, Nigeria. Three bunches each of landrace plantains (AAB):-Agbagba and Obino l 'Ewai; hybrid plantains (AAAB):-TMPx548-4 and TMPx 548-9 and cooking bananas (ABB):-Cardaba and Bluggoe were harvested from the farm of Plantain Banana Improvement Programme (PBIP) of IITA during the months of July-September at the maturity stage (i.e., 13-15 weeks after floral emergence). Throughout the experiments the laboratory used was maintained at 25°C and 78% relative humidity, and the fruits were ripened naturally.

Experiment 1: Determination of postharvest life (rate of respiration and ripening) of *Musa* fruits

Ripening of fruits was monitored by recording visual colour change of fruit peel according to Ferris (1992): *Stage 1* (100% green), *Stage 4* (50 % yellow:50% green), *Stage7* (100% yellow) *Stage10* (100% brown). Frequency of ripening was measured as the number of days a fruit stays at a particular stage of ripening before passing to the next one. Postharvest usability-life was measured as the number of days taken for a fruit to reach stage 10. Respiration rate was determined by the method of Claypool and Keefer (1942) (using continuous flow system) and calculated with the formula:

Rate of respiration = (Milliliters of CO_2 produced x V) / W x T

Where V = Volume of container
W = weight of fruit T = Time (hours)

The experimental design was a completely randomized block design with cultivar and stage of ripening as sources of variation. For each measurement, three fingers were picked randomly from the second hand of three bunches for each cultivar used. Analyses of variance (ANOVA) and regression procedures were performed using Statistical Analysis System (SAS) package version 6.0.

Experiment 2: Evaluation of *Musa* fruits for physical strength

Impact and compression injuries were simulated on whole bunches to evaluate the effect of careless harvesting and loading techniques on *Musa* fruit. Peak force was used to denote the amount of energy absorbed by a falling fruit (impact stress) according to Schoorl and Holt (1983). This parameter was calculated by using the formula:

Peak Force = m x h x g

where **m** is mass (kg) of the falling fruit,

h is net height (i.e., drop height minus the rebound height) (m)

g is acceleration due to gravity (ms^{-2})

Six bunches from each variety were allowed to fall through a known height (4-8 meters) to the ground to simulate the situation happening during harvesting, loading and unloading. The mean of peak forces values for six bunches provided peak force value for each variety. The experiment was repeated with bunches of different weights falling from different heights so as to generate three levels of peak force for each cultivar. The experiment was designed thus: 6 cultivars X 3 peak force levels X 6 replicates. After treatment the effects of absorbed energy on fruits were determined via percentage fingers broken, percentage weight loss, percentage pulp damage and days required to reach stage 7. Pulp damage is a measurement of the proportion of damaged (corky texture- inedible) fruit pulp to non-damaged (normal texture) edible pulp.

Compression or static pressure was applied by stacking ten bunches of *Musa* fruits to a height of 4-5 meters as is done in commercial lorries. Stacks (two replications) were kept for 48h to simulate long distance journey, though without motion. Fruit at the topmost layer served as control. Afterwards the fruits were checked for percentage weight loss during ripening and number of days required to ripen (reach stage 7).

RESULTS AND DISCUSSION

There were significant (P 0.05) variations in usability-life and frequency of ripening of *Musa* fruits (Table 1). Hybrid plantains had the longest usability-life (22 days) while

Cooking banana had the least (13 days). Hybrid plantain had the slowest (4.3 days) ripening frequency and an average of 8.0 days before reaching stage 7, while cooking banana and the landraces took 3.5 and 5.0 days respectively. For all cultivars tested, the fastest frequency of ripening occurred when fruit were at ripening stage 4 (turning stage) (Table 1) where the average ripening frequency of 2.3 days was significantly (P0.05) different from that at stages 1 and 7 (3.0 and 4.1 days respectively). The longer ripening period and usability-life of hybrid plantains is an advantage with respect to storage and processing. Long ripening period implies more usability in terms of green life potency. Ripening stage 4 could be referred to as the *"critical stage"* in the transitional life of *Musa* fruit since all the fruits displayed fastest frequency of ripening at this stage. The implication of this is that processing involving only green *Musa* fruits should be carried out on or before the fruits get to stage 4 of ripening. Conversely, processors using ripe fruit should get ready for work once their fruits are at ripening stage 4.At the climacteric peak, respiration rates of Obino l'Ewai and TMPx 548-9 were 301 and 181 $mgCO_2^{-1}kgh^{-1}$ respectively (Figure 1).

The hybrids exhibited lower respiration rates than the landraces. Regression analysis (Figure 2) showed that high respiration rate was related to short ripening period. Though this statement did not apply to Bluggoe (cooking banana), which had short ripening period and slow respiration rate. No wonder the R^2 for the regression graph is low (23%). The result of regressing respiration rate on ripening confirms previous statements that fruit with a high respiration rate has a short green-life (Marriott and Lancaster, 1983).

High respiration value of Obino l'Ewai could be the reason for its high weight loss rate and short ripening period as observed by Cchukwu, (1997). Wainwright (1992) made a similar observation and attributed this to the larger stomatal size of Obino l'Ewai. It may be that the inclusion by breeders of the gene (CvBB) of banana into hybrid plantain gene (CvAAAB) contributed to the low respiration rate observed in the hybrid plantains. Banana is known to have a lower (250 $mgCO_2^{-1}kgh^{-1}$) respiration rate (Paull, 1994) than plantain (280 $mgCO_2^{-1}kgh^{-1}$) (Marriott et al, 1979).

Table 1: Effect of cultivar and stage of ripening on ripening frequency and usability–life of *Musa* fruit*

Cultivars		Number of days at					Usability-life
		Stage 1	Stage 4	Stage 7	Stage 10	RF	(days)
Local Plantains	**Agbagba**	3±0.4	2±0.3	5±0.1	6±0.0	**3.3**	16±2.0
	Obino l'Ewai	3±0.2	2±0.3	4±0.1	6±0.1	**3.0**	15±1.1
	Mean	**3.0**	**2.0**	**4.5**	**6.0**	**3.2**	**15.5**
Cooking Banana	**Bluggoe**	2±0.1	2±0.5	3±0.4	6±0.1	**2.3**	13±1.3
	Cardaba	2±0.1	1±0.4	3±0.3	7±0.8	**2.0**	13±1.2
	Mean	**2.0**	**1.5**	**3.0**	**6.5**	**2.2**	**13.0**
Hybrid Plantains	**TMPx548-4**	4±0.6	4±0.3	5±0.5	8±0.3	**4.3**	21±2.0
	TMPx548-9	4±0.4	4±0.3	5±03	9±0.1	**4.3**	23±2.2
	Mean	**4.0**	**4.0**	**5.0**	**8.5**	**4.3**	**22.0**
Mean		**3.0**	**2.3**	**4.1**	**7.0**		

LSD for column (cultivar) (P = 0.05) =2.0

LSD for row (Stage of ripeness) (P = 0.05) =1.7. **CV (%) = 33.8**

**Beyond stage 10 fruit pulp starts decaying*

Data are mean values for two bunches of each cultivar and stage of ripening

Rf= Ripening Frequency = average of the number of days at stages 1, 4 and 7.

In all varieties, increased CO_2 production started at stage 4, coinciding with initiation of ripening. Maximum CO_2 production occurred when fruits were at stage 7, and decreased when fruits were at stage 10
Kinetic energy absorbed by fruit affected their postharvest life (Table 2). The higher the peak force (absorbed kinetic energy) the lower the resistance of *Musa* fruits to mechanical stress (Table 3).

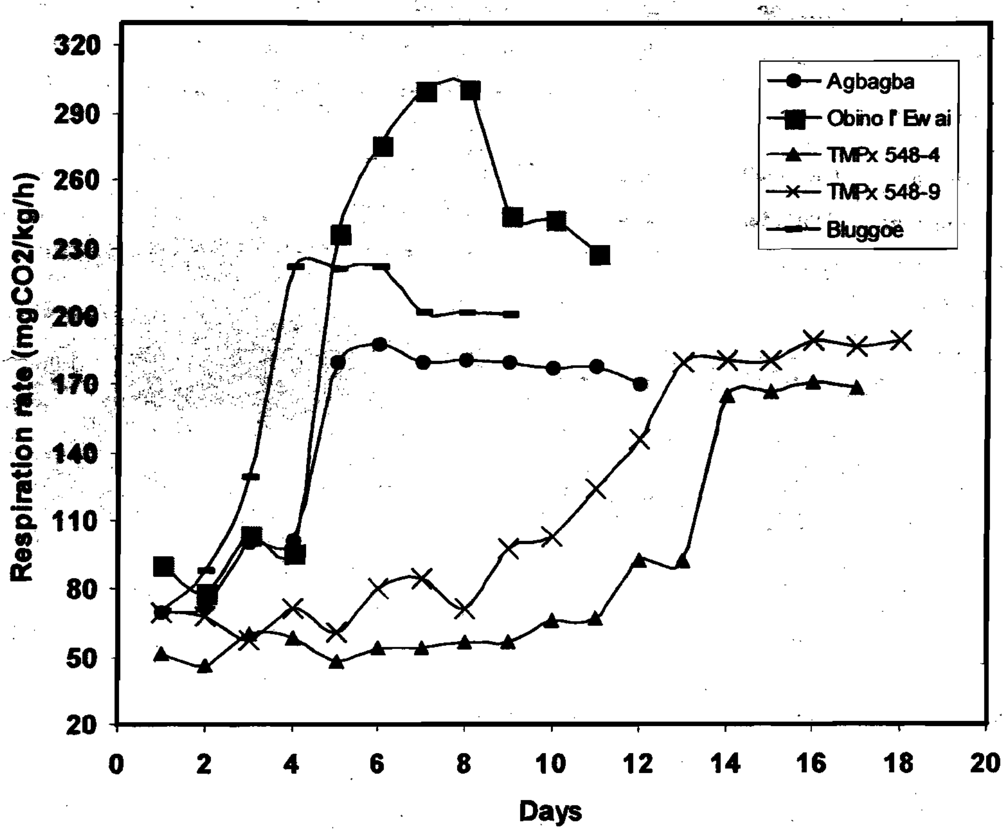

Fig 1: The respiration rate of different Cultivars of Musa spp fruit

Resading was stopped when fruit reached ripening stage 7 (100% yellow colour). It did not extend to ripening tage 10 (black colour)

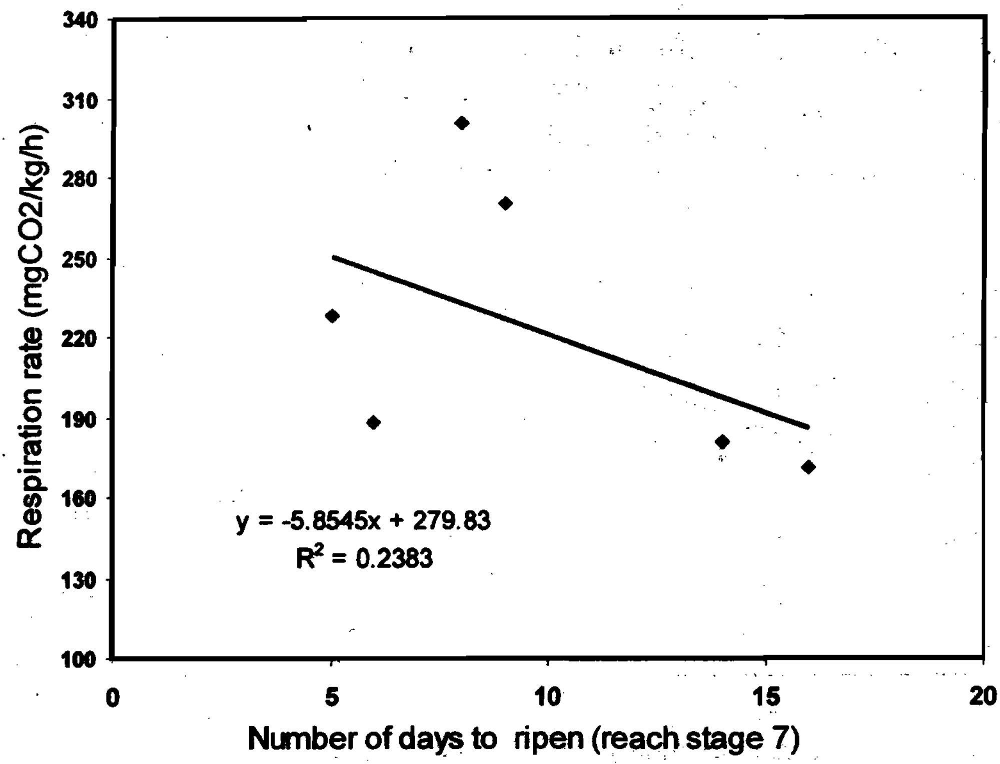

Fig 2. Regression of respiration rate (climacteric peak) on postharvest life of Musa fruits.

Increased ($p=0.05$) percentage weight loss and pulp loss occurred as peak force increased.

Peak force (above 200 Joules) caused more broken fingers than did lower peak forces (Table 3). There appeared to be differences in resistance of *Musa* varieties to mechanical stress during harvesting (Table 2) though the data set was not analysed statistically because the experiment was not fully replicated. Agbagba had the lowest (6.5%) percentage fingers broken as a result of impact stress compared with Cardaba (10%) and the hybrid plantains (14.7%) The high resistance of Agbagba and Cardaba to mechanical stress is probably as a result of the thick peel of these varieties. According to Ferris (1992) robust peel acts as a cushion, which resists mechanical stress in fruit.

Table 2: Resistance of different *Musa* fruits to mechanical (peak force) stress*

Cultivar	Peak force(J)	NF per bunch	%NF broken	Days to ripen (stage7)	Weight loss (%)	Pulp Damage (%)
Agbagba	1-200	30	0	5.5	8	0
Agbagba	201-400	31	6.5	4.5	10	4
Agbagba	401-600	31	13	4.0	13	5
Agbagba	Control	31	NA	6.2	8	NA
Agbagba	**Mean**	**30.8**	**6.5**	**5.05**	**9.8**	**3.0**
Cardaba	1-200	60	5	5.2	5.3	0
Cardaba	201-400	67	12	5.3	5.6	6
Cardaba	401-600	68	13	4.1	8.8	7
Cardaba	Control	66	NA	5.5	5.0	NA
Cardaba	**Mean**	**65.2**	**10**	**5.03**	**6.2**	**4.3**
TMPx548-9	1-200	138	6	14	10	12
TMPx548-9	201-400	142	18	12	13	16
TMPx548-9	401-600	148	20	10	15	25
TMPx548-9	Control	150	NA	16	10	NA
TMPx548-9	**Mean**	**144.5**	**14.7**	**13.0**	**12.0**	**17.7**

**Average of six bunches for each cultivar*

Peak force =(Absorbed kinetic energy)

NF:= Number of fingers

NA = Not Applicable
Control bunches were not allowed to hit the ground during harvesting

Although differences in weight loss and ripening period of bunches of *Musa* fruit stored at the top, middle and bottom of a stack of bunches were not significant (p=0.07), a trend of increased stress was exhibited as static pressure increased (Table 4). Bunches at the bottom had more stress, expressed in higher weight loss value and shorter ripening period than those at the top.

Physically injured fruit fingers caused the reduction in ripening period of harvested *Musa* bunches. Cuts and breakage have been identified as major causes of premature deterioration in fruit because they initiate physiological and pathogenic stress (Karikari et al, 1980). The consequential effect of physical injury on fruit quality demands that handlers do not:

(i) allow bunches fall to the ground at harvest
(ii) throw bunches onto or off trunks onto hard surfaces
(iii) stack bunches too high (more than 10 layers) without baffles

Use of horizontal dividers (baffles) inside distribution vehicles may reduce static pressure on fruits, although it will reduce the number of bunches in a stack. In the export of dessert bananas, fingers are stored in boxes to prevent static loading, and boxes are only stacked to a specific height to avoid damage to the boxes. Unfortunately containers are not used for plantain distribution in Nigeria. Nevertheless static pressure on *Musa* fruits could be reduced by shortening the delivery period to 4-6 hrs against 10-15hrs as is currently the case. Practically, this is not feasible in the present Nigerian situation because of bad roads, but may work well in future.

CONCLUSION

The characteristics of hybrid plantains, which include long postharvest-life, slow rate of respiration and of ripening compared with the local varieties is desirable. They are expected to have higher usability-life particularly when processed green. However, the performance of hybrid plantains with respect to mechanical strength (handling) requires some improvements. Improvement on the mechanical strength of the hybrids calls for breeder's attention to enable the fruit to withstand the rigorous distribution system in Africa. Market acceptance of the new breeds considering their weaker mechanical strength also needs to be investigated. In the mean time considering the other desirable characteristics of hybrid plantains, they are recommended for adoption. However, the processing facilities would be located close to the production sites. Cooking banana exhibited a strong mechanical strength suitable for the prevailing fresh fruit distribution system in Nigeria.

Table 3: Pooled data for effect of peak force on postharvest life of *Musa* fruits*

Peak Force (J)	NF per bunch	%N F broken	Days to ripen	Weight loss (%)	Pulp loss (%)
Control	82	NA	9.2	7.7	NA
1-200	76	0.0	8.2	7.7	3.0
201-400	80	12.2	7.3	9.5	8.7
401-600	82	15.3	6.0	14.3	12.3

**Data are average value for all the cultivars on Table 2*
*Peak force = Absorbed kinetic energy (weight of fruit * net height of falling * gravity)*
NF = Number of fingers NA = Not Applicable

Table 4: Effect of bunch position (static pressure) on ripening period and weight loss (%) of *Musa* fruit

Bunch position on the stack	Days to ripen (stage 7)	Weight loss (%)
Top	6.0	13.3
Middle	6.0	13.7
Bottom	5.0	13.8
CV (%)	**8.6**	**19.7**
LSD (P=0.07)	**1.0**	**6.2**

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