DEVELOPMENT

Vitamin A Banana/Plantain

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Target Micronutrient		Vitamin A	
Target Countries		Sub-Saharan Africa (Democratic Republic of Congo (DRC), Burundi)	
Content in Local Varieties (fresh weight – FW)		10–18 parts per million (ppm) (1)	
Content in Introduced Varieties (FW)		17–106 ppm (1)	
Nutrition Factors		**Original Assumption**	**Measured/ Revised**
Banana/Plantain Consumption, grams/day (FW)	Women	500 g/d	700–1,100 g/d (2)
	Children	200 g/d	250 g/d (unpublished)
β-carotene Bioaccessibility (%)*	ABB Plantain	8%	16% (3)
	East African Highland Bananas (EAHBs)	8%	27% (3)
Releases			
Fast-track Identified	17–106 ppm		DRC, Burundi – official release of 5 varieties planned in 2014
2nd Wave	At least 4 varieties		Planned 2016

***Bioaccessibility** refers to the amount of the β-carotene available for absorption after digestion; bioavailability data, which measures the amount digested, absorbed, and utilized, is not yet available.

Breeding banana/plantain (*Musa*) is complex, as commercial varieties are sterile triploids (3X). Among the fertile groups, a high degree of cross incompatibility can exist. Further, the *Musa* crop cycle is long. Initially, high-provitamin A African *Musa* varieties adapted under relevant conditions in African target countries were evaluated and deployed to farmers along with crop management recommendations. In the longer term, breeding combines the best provitamin A sources with African elite varieties, which carry the productivity, disease and virus resistance, and sensory traits farmers prefer.

During HarvestPlus Phase I (Discovery, 2003–2008), initial screening of more than 300 genotypes found 1–345 ppm provitamin A in existing banana/plantain varieties. Carotenoid content was indicative of pulp color, and maximum values for provitamin A carotenoids (pVACs) were discovered in African varieties. In general, about half of the provitamin A content is in the form of alpha-carotene, which is estimated to have a retinol equivalence of 24:1 (beta-carotene is 12:1). Adapted genotypes were evaluated for use of parents in multi-location trials in Nigeria and Cameroon, and results indicated stability for provitamin A carotenoids across environments.

Since 2006, Bioversity International has continued work with vitamin A banana/plantain. Completed activities include: germplasm screening of over 400 accessions from different regions; identification of proteins and enzymes responsible for the accumulation of pVACs in fruit of nutritionally rich *Musa* cultivars; a genome-wide study of the main gene-families involved in biogenesis carotenoid pathways; and studies for nutritional profiling and bioaccessibility of pVACs from *Musa*-based dishes.

Trials were established within Eastern Africa of *Musa* cultivars of different sub-groups (plantain, East African Highland bananas, ABB cooking bananas, AA and AAA dessert bananas, Pacific plantains, and AA cooking bananas) with total beta-carotene (t-BC) equivalents of 40–95 ppm, giving a retinol activity equivalent (RAE)[1] of more than 333 µg/100 g dry weight. Evaluation of pVAC content has gone hand-in-hand with evaluation of agronomic performance. In addition, sensory/organoleptic evaluation is also ongoing.

Comparison of conventional (left) and vitamin A banana (right); Photo by B. Ekesa

[1] A measure of vitamin A activity based on the capacity of the body to convert provitamin carotenoids containing at least one unsubstituted ionone ring to retinaldehyde. (1 microgram RAE = 1 mg retinol = 12 mg β-carotene = 24 mg other vitamin A precursor carotenoids).

Preliminary findings indicate that at least five genotypes have potential to perform well within Eastern Africa. Available results from sensory/organoleptic trials show that the introduced cultivars fare well in hedonic tests, and overall acceptance of the introduced cultivars was not significantly different from that of local cultivars. The mean total pVACs ranged from 17–106 ppm, and a significantly higher level of pVACs was observed as the fruit developed from unripe (ripening stage 1) to ripe (ripening stage 5). Six out of 9 cultivars can meet more than 100% of the vitamin A estimated average requirement (EAR) for children (1–5 years), and 4 out of 9 cultivars meet more than 90% of the EAR for women when 100g of fruit at ripening stage 5 are consumed. If adopted, consumption of the fruit itself or products derived from the cultivars could provide substantial contributions to the vitamin A intake of vulnerable population groups, such as children 6–59 months and women of reproductive age.

Future Releases: Of the 12 1st-wave varieties, 5 are being multiplied and will be officially released in DRC and Burundi between June and October 2014.

Four 2nd-wave varieties high in pVACs have been recently identified. They will be ordered from the International Musa Germplasm Collection (ITC), multiplied, and tested for their agronomic performance and acceptability within Eastern Africa.

Regional Testing: The five cultivars preferred in DRC and Burundi will also be tested through other research projects in Uganda and Tanzania.

Highlights:

- Fast-track varieties with high levels of provitamin A have been identified and are being tested (agronomic, organoleptic) by farmers in DRC and Burundi. A significant proportion of these varieties are likely to be incorporated within existing farming systems.
- Four 2nd-wave varieties have been identified, and they will be ordered, multiplied, and trials established to test their agronomic performance and acceptability in Eastern Africa.

Challenges:

- The yield (bunch size) of the vitamin A-rich varieties is relatively low compared to local varieties within similar genomic groups.
- The process of ordering, tissue multiplication, trial establishment, and continued evaluation is often longer than planned.

Varieties Selected for Dissemination in Eastern DRC and Burundi

Variety Name	Country of Origin	Genome-Sub group	Fruit Ripening Stage	Total Carotenoid Content (FW)*
Apantu	Ghana	AAB-Plantain	Unripe	46.83 ppm
			Ripe	100.71 ppm
Bira	Papua New Guinea	AAB-Pacific plantain	Unripe	43.42 ppm
			Ripe	106.38 ppm
Pelipita	Philippines	ABB-Plantain	Unripe	25.35 ppm
			Ripe	17.44 ppm
Lai	Thailand	AAA-Dessert	Unripe	nd
			Ripe	nd
To'o	Papua New Guinea	AA-Dessert	Unripe	5.60 ppm
			Ripe	77.69 ppm

*Measures of fruit samples obtained from North Kivu, frech weight (FW) determined by establishing moisture content following measurement of fresh sample and freeze dried sample [value of dry matter/ (100/100-moisture %)].
nd= No data because To'o mature fruit was not available in North Kivu during sample collection thus not analyzed at the moment
A=Acuminata, AA= Diploid Acuminata, AAA=Triploid Acuminata, B=Balbisiana, BB=Diploid Balbisiana

1. Ekesa BN; et al. 2013. Content and retention of provitamin A carotenoids following ripening and local processing of four popular *Musa* cultivars from Eastern Democratic Republic of Congo. *Sustainable Agriculture Research* 2(2):60–75.
2. Englberger L; et al. 2003. Carotenoid-rich bananas: A potential food source for alleviating vitamin A deficiency. *Food and Nutrition Bulletin* 24(4): 303-312.
3. Ekesa BN; et al. 2012. Bioaccessibility of provitamin A carotenoids in bananas (*Musa* spp.) and derived dishes in African countries. *Food Chemistry* 133:1471–1477.