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Nutritional value of cultivars of Banana (*Musa spp.*) and its future prospects

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Abstract

Banana is the most important tropical fruit of the world. Bananas and plantains are the fourth most important food crop in the world. Currently, ~200-300 cultivars are existent in countries that grow them. Nevertheless, only few cultivars are cultivated on large scale. In some of the African countries bananas are staple food. Hence, it is essential to know the nutritional and biochemical of different banana cultivars including recent cultivars. There are wide variations reported in different banana cultivars for Vitamins (riboflavin, folate, & vitamin C), Carotenoids (β-carotene, α-carotene, lutein, & zeaxanthin) minerals (P, K, Ca, Mg, Na, Fe, Mn, Zn, Cu, & B). Inadequate intake of vitamin A, iron and zinc in the East African and South East Asia region peoples are highly affected nutritional disorders. Promoting consumption of bananas with enhanced micronutrient content as well as enriching bananas with micronutrients through breeding could go a long way towards preventing micronutrient deficiencies in the region, since bananas are a widely consumed staple. This review elaborates the nutritionally important compounds such as carotenoids, vitamins and minerals in various recent banana cultivars from different parts of the world.

Keywords: Banana, plantain, carotenoid, vitamins, minerals

1. Introduction

Banana plants are the world's foremost herbs and it's grown in several countries. However, Bananas and plantains are the world 4th prominent agricultural crop after rice, wheat, and maize. (Ganapathi *et al*., 1999) [12] and considered to be one of the most important sources of energy and starchy staple food for the people of tropical humid regions (Onwuka and Onwuka, 2005) [18]. Furthermore, bananas and plantains are rich in nutrients, starch, sugar and vitamins A and C, potassium, calcium, sodium and magnesium, Doymaz (2010) [5]. Plantains are nutritionally low protein food material but relatively high in carbohydrates, vitamins and minerals (Offem and Njoku, 1993) [17].

Moreover, latest studies on bananas grown in Africa and South America have shown that relationship between yellow-to-orange flesh coloration and higher carotenoid content (Amorim *et al*., 2009 [2]; Newilah *et al*., 2008) [16]. Carotenoids-rich banana cultivars have been identified by several studies (Englberger *et al*., 2003, 2006, 2010 [6-8]; Fungo *et al*., 2007, 2010; Fungo and Pillay, 2011) [9-11]. However, there is few published information on the variability in bananas and plantains micronutrient concentrations Wall, (2006) [21] and Fungo *et al*. (2007) [10]. This is important to initiate activities to identify the banana and plantain cultivars with high level of provitamin A and micronutrients will be encourage the growth and consumption of such acceptable cultivars in the region of vitamin A and micronutrient deficiency. Based on the above mentioned comments, it is not surprising that the nutritional benefits of *Musa* species have been attracting great interest. Therefore, the present review has been detailed updates of the *Musa* species nutritional quality and its health benefits.

2. Composition of Cultivars

Nutritional disorders due to inadequate intake of vitamin A, iron and zinc in the East African and South East Asia region are unusually high. Promotion of consumption of bananas with enhanced micronutrient content as well as enriching bananas with micronutrients through breeding could go a long way towards preventing micronutrient deficiencies in the region, since bananas are a widely consumed staple (Fungo *et al*., 2010) [11]. Bananas are considered as a rich source of vitamin A, vitamin B complex, vitamin C, manganese, potassium and digestible food fibers are present in the fruits in sizeable levels (Aurore *et al*., 2009) [3]. However, the comparable composition of fresh banana and plantain were summarized (Table 1).

3. Carotenoids concentration

The average total carotenoids concentrations and range of total carotenoids concentration of 42 banana accessions were 4.7 µg g^{-1} and 1.1-19.2 µg g^{-1} respectively, (Amorim *et al*., 2009) [2]. However, average total carotenoid concentration of 11.1 µg g^{-1} found in 21 banana accessions Englberger *et al*., (2003) [7]. Fungo *et al*., (2007) [10]. Investigated 47 banana accessions for ß-carotene, iron and zinc concentration by HPLC analysis. In results, they observed that orange pulped Papua New Guinea bananas had rich ß-carotene levels than in yellow cooking East African Highland bananas and creamy desert, juice and roasting bananas. In addition, ß-carotene concentration ranged from 2416.7 µg/100g in the Papua New Guinea accession of Dimaemamosi' to 50.6 µg/100g in the desert banana accession of 'Sukali Ndizi'. Furthermore, the average ß-carotene concentration of cooking, desert, juice and roasting bananas was 7 times less than that of the Papua New Guinea bananas (Fungo *et al*., (2007) [10]. However, β-Carotene equivalent content of selected banana cultivars from South East Asia and Micronesian compared with the common banana were summarized (Table 2)

Fungo and Pillay (2011) [9] used high-performance liquid chromatography (HPLC) to determine the ß-carotene concentration of 47 banana genotypes from the International Institute of Tropical Agriculture (IITA) germplasm collection in Uganda. Also, they used a color meter to assess the correlation between pulp color intensity and ß-carotene levels. In results, revealed that wide variability in ß-carotene levels within and among the different groups of banana studied. Banana genotypes from Papua New Guinea (PNG) had the highest levels of ß-carotene with values as high as 2594.0 µg/100 g edible pulp. Accessions with relatively high levels of ß-carotene, especially the PNG genotypes, could be deployed to regions with high vitamin A deficiency and/or be used as parents for development of vitamin dense varieties. The PNG genotypes could be useful in genetic studies related to vitamin A in banana (Fungo and Pillay, 2011) [9]. Englberger *et al*., (2006) [8], observed that great differences in the carotenoid levels and flesh colors of the 23 cultivars, ranging from 38 and 128 µg α -carotene/100 g in the white-fleshed bananas to 7200 and 8508 µg α-carotene/100 g in the orange-fleshed. Additionally, three Fe'i banana cultivars namely, Utin Iap, Utimes (which is closely related to Utin Iap), and Karat, contained the highest β-carotene levels. Furthermore, fresh Karat sample had a greater β-carotene level (2230 µg/100g), over 100 times higher than common banana and much higher compared with the other Karat study sample (960 µg/100 g) (Englberger *et al*., 2006) [8]. Englberger *et al*., (2010) [6] analyzed 10 banana cultivars from Makira, Solomon Islands for carotenoids concentration and results showed that β-carotene equivalents ranged from 45 to 7124 µg/100 g. Compared to banana cultivars with light-colored flesh, the yellow/orange-fleshed cultivars generally contained higher carotenoid concentrations (Englberger *et al*., 2003; Englberger *et al*., 2010) [7, 6]. Additionally the carotenoid concentration of selected raw ripe banana cultivars grown from different countries were presented in summarized (Table 3).

4. Vitamins

Bananas are considered as rich source of several vitamins present in their fruits. (Englberger *et al*., 2010) [6], observed that all eight Fe'i banana cultivars contained riboflavin, ranged from 0.10 to 2.72 mg/100 g, some having substantial concentrations. The nutrient-rich cultivars, including Fe'i, should be promoted for their potential to contribute to vitamin A intake and overall health. A banana cultivar Karat with 200 g edible flesh would provide three times the estimated requirement of niacin (14 mg/day) and almost one-half of the estimated requirements of a-tocopherol (7.5 mg/day) for a non-pregnant non-lactating woman (Englberger *et al*., 2010) [6]. Concentration of selected vitamins in ripe raw Karat and other banana cultivars were compared with the common banana and it's summarized (Table 4).

5. Minerals

Mineral concentrations of banana fruits grown at different countries were presented (Table 5). Fungo *et al*., (2007) [10]. investigated 47 banana accessions for iron and zinc concentration by HPLC analysis. The iron concentration ranged from 1.42 mg/100g in 'Saba' to 0.063 mg/100g in 'Kikundi' while the zinc concentration ranged from 1.219 mg/100g in 'Kivuvu' to 0.00 mg/100g in 'Kabucuragye' and 'Grand Naine'. The atomic absorption spectrophotometer analyses for iron and zinc revealed a substantial presence of iron and zinc in roasting bananas of 'Saba' and 'Kivuvu' Fungo *et al*., (2007) [10]. In another study, Fungo *et al*., (2010) [11]. evaluated 17 Papua New Guinea (PNG) banana accessions were used for determination of iron and zinc by atomic absorption spectrophotometry. Results revealed that iron and zinc concentrations ranged from 0.063 to 0.608 mg/100g and 0.00003 to 0.598 mg/100g, respectively. However, these results highlight the potential of accession variation in micronutrient composition, important for distribution and promotion for consumption in areas culturally acceptable. The variation can also assist in enhancing content of locally consumed bananas through bio fortification.

6. Future prospects

Nutritional disorders due to inadequate intake of vitamin A, iron and zinc in the East African and South East Asia region are unusually high. Interventions to alleviate these deficiencies rely on supplementation and food fortification programs, which are not sustainable and do not reach all the affected. Sustainable solutions to malnutrition can be developed through linking agriculture, nutrition, and health (Fungo *et al*., 2010) [11]. However, the success of a food-based vitamin A and other micronutrient deficiency prevention strategy based on locally grown foods depends largely on the food that is promoted. Several factors limit the potential of presently known vitamin A and micronutrients rich foods, including the vitamin A and micronutrient activity of the food, acceptability of taste, cost, availability, status and prestige, familiarity, seasonality, and size of the commonly edible portion. Bananas are one of the world's most common staple foods, and several carotenoid rich cultivars have been identified. It is stressed that there is a great need for the identification of other banana cultivars that are likely to be carotenoid-rich, based on the color of the edible portion should be analyzed with high-performance liquid chromatography (Englberger *et al*., 2003) [7]. Ethnography is suggested to be an important research method that could be used in identifying the potential carotenoid and micronutrient rich cultivars and in gathering information needed for planning food based vitamin A and micronutrient deficiency prevention strategies, including data on factors such as production, consumption and acceptability. Furthermore, the efforts should be focused on those areas of the world where bananas are an accepted staple food. Studies are required to determine the impact that carotenoids and micronutrient rich cultivars will have on improving vitamin A and micronutrient status. The genetic engineering based research needed to increase ß-carotene, iron and zinc content in the bananas through bio fortification to levels which are higher than the current ones. In addition, plant breeders need to breed superior concentrations of the three nutrients in banana cultivars through cycles of recurrent selection.

7. Conclusion

Numerous studies provided evidence that flesh color can be used to screen for carotenoid-rich banana cultivars. The greater carotenoid concentration of the identified banana cultivars provides a good case for the introduction and distribution of these cultivars in countries where vitamin A deficiency (VAD) is high. Providing consumer acceptability, this could provide a quick solution to vitamin A deficiency. Moreover, consumption of rich Iron and Zinc banana cultivars could be have potential to alleviating micronutrient malnutrition deficiency in developing countries. Fe'i banana cultivars contained rich riboflavin concentrations that could potentially meet daily estimated riboflavin requirements, according to traditional eating patterns. Nevertheless, in future the Genetic engineering technologies has to help the increase carotenoids and micronutrients in the bananas through bio fortification to levels which are higher than the current ones.

Table 1: Comparable composition of fresh banana and plantain

Constituents	Unit	Banana *Musa* spp.	Plantain *Musa* spp.
Energy	Kcal	89	122
Water	g	74	65
Protein	g	1.1	1.3
Total lipid	g	0.3	0.4
Carbohydrate	g	21.8	32
Fibre	g	2	2.0-3.4
Sodium	mg	1	4
Potassium	mg	385	500
Calcium	mg	8	3
Magnesium	mg	30	35
Iron	mg	0.4	0.6
Phosphorus	mg	22	30
Vitamin C (Ascorbic acid)	mg	11.7	20
Equivalent β. carotene	µg	68	390-1035
Thiamin (Vitamin B1)	µg	40	80
Riboflavin (Vitamin B2)	µg	70	40
Niacin	µg	610	600
Pantothenic acid (Vitamin B5)	µg	280	na
Pyridoxine (Vitamin B6)	µg	470	na
Folic acid	µg	23	na

Source: Modified table adopted from Aurore *et al*., (2009) [3]; na, data not available

Table 2: β-Carotene equivalent concentration of selected banana cultivars from South East Asia and Micronesian compared with the common banana

Scientific name	Cultivar / Local name	Origin	Classification	β-Carotene equivalent (µg/100g)[a]	References
Musa sp.	*Utin Iap*	Pohnpei	Fe'i	8508	Englberger *et al*. (2006)
Musa sp.	*Aibwo/Suriya#1*	Makira Island	Fe'i	7124	Englberger *et al*. (2010)
Musa sp.	*Aibwo/Suria#2*	Makira Island	Fe'i	3331	Englberger *et al*. (2010)
Musa sp.	*Karat*	Pohnpei	Fe'i	2473	Englberger *et al*. (2006)
Musa sapientum var *tuldoc*	*Tundok*	Philippines	AAB; Horn Plantain	1370	Abdon and Rosario, (1980)
Musa sp.	*Huki Matawa*	Guadalcanal	AAB; Maoli/Popoulu	443	Englberger *et al*. (2010)
Musa sp.	*Pisan Rajah Buluh*	Malaysia	AAB; Pisang Raja	420	Siong, (1985)
Musa sp.	*Pisang Mas*	Malaysia	AA; Sucrier	420	Siong, (1985)
Musa sp.	*Pisang Tandok*	Malaysia	AAB; Horn Plantain	370	Siong, (1985)
Musa sp.	*Lakatan*	Philippines	AA; Lakatan	360	Abdon and Rosario, (1980)
Musa sp.	*Kluai Khai*	Thailand	AA; Sucrier	345	Puwastien *et al*. (1999)
Musa sp.	*Pisang Susu*	Malaysia	AAA; Pisang Susu	330	Siong, (1985)
Musa sapientum var *ternantensis*	*Ternate*	Philippines	AAB; Pisang Raja	325	Abdon and Rosario, (1980)
Musa sp.	*Pisang Rajah Udang*	Malaysia	AAA; Red	290	Siong, (1985)
Musa sp.	*Tangrat*	Yap	AAB; Maoli/Popoulu	290	Englberger *et al*. (2006)
Musa sp.	*Hug-mook, Silver Bluggoe*	Thailand	ABB: Bluggoe	279	Puwastien *et al*. (1999)
Musa sp.	*Pisang Beragan*	Malaysia	AA: Lakatan	230	Abdon and Rosario (1980)
Musa sp.	*Utin Menihle*	Pohnpei	AAB; Silk	128	Englberger *et al*. (2006)
Musa sp.	*Saena*	Guadalcanal	AAA; Cavendish	98	Englberger *et al*. (2010)
Musa sp.	*Common banana*	Unspecified	AAA; Cavendish	21	Holden *et al*. (1999)

[a]Content of β-carotene plus one-half of the content of α-carotene and β-cryptoxanthin.

Table 3: Carotenoid concentration of selected raw ripe banana cultivars (µg/100 g edible portion)

Cultivar name	Origin	Colour of the flesh	Classification	β-carotene	Lutein	Zeaxanthin	Total carotenoids	References
Aibwo/Suria#1	Makira	Yellow/orange	Fe'i	5945	na	na	9400	Englberger *et al*. (2010)
Ropa	Makira	Yellow	AAA	1324	na	na	5218	Englberger *et al*. (2010)
Karat	Pohnpei	Yellow/orange	Fe'i	2230	1130	137	4320	Englberger *et al*. (2006)
Aibwo/Suria#2	Makira	Yellow/orange	Fe'i	2572	na	na	4185	Englberger *et al*. (2010)
Warowaro	Makira	Yellow	Fe'i	166	na	na	1444	Englberger *et al*. (2010)
Toraka Parao	Makira	Yellow/orange	Fe'i	526	na	na	776	Englberger *et al*. (2010)
Gatagata/Vudito #1	Guadalcanal	Yellow/orange	Fe'i	695	na	na	774	Englberger *et al*. (2010)
Huki Matawa	Guadalcanal	Yellow	AAB; Maoli/Popoulu	296	na	na	589	Englberger *et al*. (2010)
Gatagata/Vudito #2	Guadalcanal	Yellow/orange	Fe'i	447	na	na	489	Englberger *et al*. (2010)
Tangrat	Yap	Yellow	AAB; Maoli/Popoulu	220	60	na	400	Englberger *et al*. (2006)
Utin Iap	Pohnpei	Orange	Fe'i	8508	na	na	na	Englberger *et al*. (2006)
Dwarf Brazilian	Hawaii	na	na	96.8	154	na	na	Wall, (2006)
Williams	Hawaii	na	AAA	55.6	108	na	na	Wall, (2006)
Pisang Mas	ITC-Belgium	Orange	AA	1138.7	na	na	na	Fungo and Pillay (2011)
GCTV 215	ITC-Belgium	Creamy	AAA	577.4	na	na	na	Fungo and Pillay (2011)
Dwarf Cavendish	ITC-Belgium	Creamy	AAA	460	na	na	na	Fungo and Pillay (2011)
Grand Naine	ITC-Belgium	Creamy	AAA	447.1	na	na	na	Fungo and Pillay (2011)
IC2	ITC-Belgium	Creamy	AAAA	401.8	na	na	na	Fungo and Pillay (2011)
Dimaemamosi	Papua new guinea	Orange	AA	2416.7	na	na	na	Fungo and Pillay (2011)
Galeo	Papua new guinea	Deep yellow	AA	1254.9	na	na	na	Fungo and Pillay (2011)
Pitu	Papua new guinea	Creamy	AA	1127.3	na	na	na	Fungo and Pillay (2011)
Pongani	Papua new guinea	Light yellow	AA	213	na	na	na	Fungo and Pillay (2011)
Utin Menihle	Pohnpei	White	AAB; Silk	128	na	na	na	Englberger *et al*. (2006)
Bluggoe	Uganda	Creamy	ABB	240.2	na	na	na	Fungo and Pillay (2011)
Mshale	Tanzania	Creamy	AA	316.9	na	na	na	Fungo and Pillay (2011)
Saena	Guadalcanal	White	AAA; Cavendish	na	na	na	137	Englberger *et al*. (2010)
Akeakesusu	Makira	Yellow	Fe'i	na	na	na	130	Englberger *et al*. (2010)
Essong	Cameroon	Orange	AAB	1504	na	na	na	Gerard *et al*. (2009)
Dwarf kalapua	Cameroon	Ivory	ABB	125	na	na	na	Gerard *et al*. (2009)
Grande Naine	Cameroon	Cream	AAA	586	na	na	na	Gerard *et al*. (2009)
CRBP 39	Cameroon	Ivory	AAAB	1694	na	na	na	Gerard *et al*. (2009)
CRBP 755	Cameroon	Ivory	AAA	1961	na	na	na	Gerard *et al*. (2009)
DS 11	Cameroon	Orange	AA	2347	na	na	na	Gerard *et al*. (2009)

na; data not available

Table 4: Concentrations of selected vitamins in ripe raw Karat and other banana cultivars (mg/ 100g edible portion) compared with the common banana

Cultivar name	Classification	Riboflavin	Thiamin	Niacin	Vitamin B6, Pyridoxines	Folate	Vitamin C, Ascorbic acid	Vitamin E, α-tocopherol	Reference
Karat	Fe'i	14.30	na	na	na	0.030	na	na	Englberger *et al*. (2006)
Gatagata/Vudito #2	Fe'i	2.72	na	na	na	na	na	na	Englberger *et al*. (2010)
Utin Iap	Fe'i	1.76	na	na	na	0.013	na	na	Englberger *et al*. (2006)
Gatagata/Vudito #1	Fe'i	1.29	na	na	na	na	na	na	Englberger *et al*. (2010)
Toraka Parao	Fe'i	0.54	na	na	na	na	na	na	Englberger *et al*. (2010)
Aibwo/Suria#2	Fe'i	1.09	na	na	na	na	na	na	Englberger *et al*. (2010)
Utin Menihle	AAB: Silk	0.47	na	na	na	0.020	na	na	Englberger *et al*. (2006)
Akdahn Weitahta	AAA: Red	0.38	na	na	na	0.013	na	na	Englberger *et al*. (2006)
Aibwo/Suria#1	Fe'i	0.26	na	na	na	na	na	na	Englberger *et al*. (2010)
Dwarf Brazilian	na	na	na	na	na	na	12.7	na	Wall, (2006)
Williams	na	na	na	na	na	na	4.5	na	Wall, (2006)
Common banana	AAA: Cavendish	0.06	0.04	0.7	0.29	0.014	11.0	0.27	Holden *et al*. (1999)

na; data not available

Table 5: Mineral concentration of banana fruits grown at different countries

Cultivar name	Ploidy	Origin	P	K	Ca	Mg	Na	Fe	Mn	Zn	Cu	B	Reference
			mg/100g fresh weight										
Dwarf Brazilian	na	Hawaii	26.3	342.4	7.3	39.4	16.1	0.75	0.66	0.36	0.26	0.16	Wall, (2006)
Williams	AAA	Hawaii	21.7	318.9	4.9	28.8	17.4	0.83	0.20	0.21	0.25	0.14	Wall, (2006)
Nakhaki	AAA	Uganda	na	na	na	na	na	0.61	na	0.54	na	na	Fungo *et al*. (2007)
Nakitembe	AAA	Uganda	na	na	na	na	na	0.51	na	0.34	na	na	Fungo *et al*. (2007)
Kikundi	AAA	Tanzania	na	na	na	na	na	0.06	na	0.21	na	na	Fungo *et al*. (2007)
Dwarf Cavendish	AAA	ITC-Belgium	na	na	na	na	na	0.46	na	0.56	na	na	Fungo *et al*. (2007)
Sukali Ndizi	AAB	Uganda	na	na	na	na	na	0.16	na	0.14	na	na	Fungo *et al*. (2007)
Pisang Awak	ABB	ITC-Belgium	na	na	na	na	na	0.26	na	0.29	na	na	Fungo *et al*. (2007)
Kisubi	AB	Uganda	na	na	na	na	na	0.19	na	0.21	na	na	Fungo *et al*. (2007)
Saba	ABB	ITC-Belgium	na	na	na	na	na	1.42	na	0.52	na	na	Fungo *et al*. (2007)
FHIA 25	AAAA	Honduras	na	na	na	na	na	0.34	na	0.74	na	na	Fungo *et al*. (2007)
FHIA 03	AAAB	Honduras	na	na	na	na	na	0.33	na	0.60	na	na	Fungo *et al*. (2007)
TMB5610	AA	Uganda	na	na	na	na	na	0.22	na	0.04	na	na	Fungo *et al*. (2007)

na; data not available

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