REVIEW ARTICLE

An Overview on Phytochemical Composition of Banana (*Musa spp.*)

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ABSTRACT

Banana (*Musa spp.)* the most significant of all the tropical fruits .All the known cultivars of banana are a rich, diverse source of many of the chief dietary health-promoting phytochemicals like carbohydrates, potassium, vitamin C, fibre and provitamin A carotenoids. Beta-carotene is the precursor of vitamin A. Vitamin A deficiency is the most common dietary problem in malnutritioned children, around the globe. Many epidemiological studies have found out that augmented intake of plant-based foods with rich nutritions are interrelated with a reduced threat of several diseases like cancers and cardiovascular diseases. Hence, food based approaches are the most profitable and sustainable strategies for the prevention of Vitamin A deficiency. So, a complete survey of all the genetic diversity available within the sexually compatible species of banana becomes very indispensable at this moment. It is also necessary to understand the many attributes like botanical, agronomic, nutritional and processing quality of the fruits. Due to the very huge number of genetic diversity present in the *Musa* species, regrettably, only modest data are available regarding the nutritional composition of even the wild species and the popular, often traded modern cultivars of banana. The review elaborates the precious bioactive compounds such as carotenoids and vitamin C and carbohydrates present in the pulp and peels of selected banana cultivars against the traditional cultivars of banana fruits.

Keywords : Banana, carotenoid, vitamin C, nutritional levels

INTRODUCTION

Bananas are edible ripe berries [7] [8] [9] [32] [37] of the herbaceous flowering plants in the genus *Musa*. *Musa* belongs to a genus containing 50 of tropical monocot (pseudo) plants, significant for food, primarily for their delicious fruits, beverages (wine and beer), fiber for industry and as ornamental plants. The genus, of the wet tropical worlds, is the fourth most cultivated food crop in the world.They are different is sizes and fruit colour and are elongated and curved, with soft flesh full of starch covered with a peel which is usually found in a gamut of colours like green, yellow, red, purple, or brown when ripe. All modern cultivars are edible parthenocarpic (seedless) bananas domesticated from two wild species – *Musa acuminata* and *Musa balbisiana* (wild progenitors of the complex hybrids). Musa species are indigenous to the tropical Indomalaya and Australia, and have been first domesticated in Papua New Guinea [39]. They are cultivated in at least 107 countries [37]. But the archaeological and palaeological evidences propose that banana cultivation dates back between 5,000 B.C. and perhaps, to 8,000 B.C. As per these records, *Musa* species is expected to have originated and were domesticated in south east Asia. Bananas are considered to be a vital food source in Southeast Asia and Africa, and as a chief food commodity in export in Central and South America.

The word banana was first used in West Africa, and later spread on to from the English through the Spanish or Portuguese [37]. Bananas and plantains are developed from the same species, but they are different in ratio of sugar to starch. In the Americas and Europe, soft, pliable, sweet, dessert bananas, belonging to the Cavendish group are referred to as “bananas”. These cultivars with high sugar are eaten fresh or cooked when green. But the ones which are firmer and starchier fruits are called "plantains", which are with high starch are eaten only after cooking. They both are high in carbohydrates, fiber, potassium, magnesium, phosphorus, and several vitamins. Bananas are eaten fresh, pureed for baby food, and cooked in assorted dishes typical of tropical cuisines. Fruits, leaves, and stems have plentiful traditional medicinal uses, counting as a drug for dysentery, diarrhea, and many more digestive disorders (Morton, 1987).

The genus *Musa* was fashioned by Carl Linnaeus in 1753[37]. A number of 70 species of Musa were documented by the World Checklist of Selected Plant Families [26]. Linnaeus was the first to place bananas into two species on the basis of their uses as food: *M. sapientum* for dessert bananas and *M. paradisiaca* for plantains. Subsequently further species names were added [9].In 1947, Cheesman, based on the pre-Linnaeuian description by Luigi Aloysius Colla refined that Linnaeus's *M. sapientum* and *M. paradisiaca* were only descendants of two wild seed-producing species, *M. acuminata* and *M. balbisiana* [9,37]. Later, Norman Simmonds and Ken Shepherd projected a genome-based nomenclature system in 1955. According to this system, all discrepancies and inconsistencies of the earlier classification were eliminated. At present, the majority of cultivated bananas are accepted as *M. acuminata Colla* and *M. balbisiana Colla* for the ancestral species, and *M. paradisiaca L.* for their hybrid [32]. The cultivars are positioned in groups based on their number of chromosomes and the species from which they are derived. The AAB Group is a triploid derivative of *M. acuminata* (A) and *M. balbisiana* (B). Figure 3.

Botanical aspects

Musa species belongs to the Family, Musaceae. It is commonly referred to as Banana, Bananier Nain, Canbur, Curro and Plantain. The common species among the cultivars is *Musa acuminata Colla*, *M. paradisiaca L.* (hybrid). Some of the few related species are Abyssinian Banana (*Ensete ventricossum Cheesman*), *Musa balbisina Colla*, *M. ornata Roxb.* and *M. textilis Nee.*[32],[37].

The plants emerge like to be trees and raise upto 3.5 to12 meters. But *Musa* species are in principle, perennial herbaceous plants due to their rigid, tough, fibrous pseudo-stems made of overlapping bases of the large, spirally arranged leaves (8 to 20 per plant). The leaves are of 2.4 to3.7 meters long and half a meter wide. The prime stem produces a single huge terminal inflorescence which is a spike. The spike is made up with pistillate or female flowers in the bottom and staminate or male flowers at the top. This spike later on maturity turns beautifully into a cluster of bananas, mostly consisting of 6 to9 clusters of 10 to 25 bananas each. They are placed spirally all around the central stalk of the cluster called as the peduncle. Generally, a bunch of banana weighs around 22–34 kg, but sometimes may reach around 70 kg. A single flowering process leads to the completion of the main stem which dies paving way for new stems to rise up from the rhizome/corm under the soil [32].

These herbaceous perennial plants are very fast in growth from the underground corms. The fibrous and fleshy fresh pseudo stems are placed in concentric circles of sheaths of leaves, facing the sun which comprise of the trunks. Though, the main true stem starts growing from the corm from inside the soil. It is pushed outwards towards the sun from the centre of the stalk after 10 to 15 months from planting. During the time of flowering, the terminal inflorescence emergers and bears into the fruit. Every stalk of the plant bears one heavy flower, matures into a fruit cluster and then dies. The bananas are exceptionally decorative only next to palm trees in the tropics and they are a main element in landscaping(5).Figure 1.

The very big oblong or elliptic leaf blades are extended from the sheaths of the pseudo-stem. They are united by plumpy, deeply ridged, little petioles. As the plant grows, the leaves open out from the whorls at the rate of one per week under humid conditions. They lengthen upward and outward, to as much as 9 feet long and 2 feet wide. They are found to be wholly green, green with mixed reddish purple splotches, or green on the upper side and red-purple underneath. The veins of the leaf run from the mid-rib out straight to the outer rim of the leaf. A very wonderful fact about the veins of these leaves is that even after shredding, they are able to function. Roughly 40 to 45 leaves emerge prior to the bearing of the inflorescence.Figure. 2.

The inflorescence of banana spurts out from the heart of the pseudo-stem. It is, initially, a bulky, long-oval, narrowing, purple-coloured bud. The slender, nectar-rich, tube-like, toothed, white flower slowly opens up later. Double rows of whorls are clustered around the floral stalk and each of the clusters is sheathed into by a chunky, waxy, hood like bract that is purple-clad on the out and dark red inside. The florets present in the first 5 to 15 rows are female (Figure 2). The inflorescence keeps on elongating as the rachis of the flower grows out with sterile flowers with abortive male and female parts. Later, normal staminate ones with abortive ovaries are formed on elongation. The two lately formed flower types finally dry and die back in almost all edible cultivars [6,7,8,9].Parthenocarpic (without pollination) fruits are produced from the ovaries present in the first female flowers of the fruit clusters which are called the hands. The number of hands differs with the species and cultivar/variety. The berry changes colour from deep green to yellow or red. They are from 2 to 12 inches in length and 2 inches in width. The pulp is ivory-white in colour or may be yellow and may be rigid, produce latex when unripe. On ripening they turn into a tender, slippery to a soft and mellow starchy flesh. The aroma is commonly soft and sweet. The pulp is seedless but few vestiges of ovules are visible as brown specks in all common cultivars.

Bananas grow in almost all soil types except salty ones. They are found to be very productive if planted in nutrient rich, well-drained soils. Soils fed with heavy compost heaps with a preferable acidic pH between 5.5 and 6.5 are very suitable. The thick chunky banana plant enjoys great amounts of water. Customary profound watering is a total necessity and drying is definitely detrimental under hot climatic conditions. Standing water causes the root to rot. Thick mulching preserves moisture and the fibrous roots. Bananas and plantains belong to the humid tropical regions. About 10 to 15 months of frost-free weather supports very healthy flower stalk production Almost all varieties stop growing below 53° F. the plant growth slows down at about 80° F and stops at a temperature of 100° F. Scorching of leaves and fruit happens at higher temperatures. Freezing temperatures certainly kill the plant completely. They are very susceptible to be blown away in strong winds.

Biochemical composition of banana fruit

Bananas are consumed as fresh, dried, cooked or baked recipes. The biochemical composition of riped fruits mainly depends on the cultivar/variety, abiotic and environmental factors and the nutrient status and the nature of the soil (2). Bananas are considered as an abundant source of vitamin B6. Vitamin C, manganese and digestible food fibers are present in the fruits in sizeable levels.[1,3,19] About [40] 358 mg of the potassium is present in every 100 g of the fruit, thus making it an easily accessible source of the nutrient to the common man.

As a major staple source of starch to a many of the populations in the tropics, the flesh of bananas can diverge from starchy to sugary in flavor and firm to squashy in texture. This is mainly due to the factors like the cultivar quality and the stage of ripening. The inner pulp and even the skin are edible, raw or cooked. Isoamyl acetate also called as banana oil, is the primary chemical component yielding the peculiar fragrance of fresh fruits. Butyl alcohol and isobutyl alcohol are also role players in the pleasant flavor of the banana cultivars/varieties [20,23,24,25,26]

Ripening induces the production of ethylene gas which is a plant hormone that indirectly affects the flavor of the fruit. Ethylene stimulates the production of the enzyme amylase which breaks down starch into sugar. So the pulp turns very sweet to eat. Yellow bananas are much sweeter because of the higher concentrations of sugar molecules than greener bananas which are only starchier in taste. Ethylene production also initiates the synthesis of the enzyme pectinase to act upon the pectin between the cells in the pulp. This results in the softening of the tissues on ripening.[24,28].Figure 4.

Higher potassium to sodium content present in bananas are helpful in preventing high blood pressure and its other related complications [40]. The rich levels of fiber content also contribute to the same effect. Renal calcium losses and so a huge effect in the prevention of bone breakdown is found to be connected with the higher levels of potassium in the fruits of banana.[31] During diarrhea, the fruits help by contributing with the replacement of electrolytes, as well as in the increased absorption of nutrients that are lost.[28] Bananas are found to prevent peptic ulcers due to their antacid effects. [30] A hydrocolloid, namely, pectin, can relieve constipation by stabilizing and lubricating the movement of the intestine. Diabetic patients have sizaeable benefits from unripe bananas because of its low glycemic index . The presence of higher contents of fructooligosaccharide which plays a role as a prebiotic, adds up in the nourishing of the intestinal flora to generate useful vitamins and enzymes. The carotenoid content of the fruit has significant antioxidant effects sufficient enough to protect against vitamin A deficiency which results in night blindness and other diseases. Regular consumption of this fruit decreases the risk of cancers in the kidney since phenolic compounds with antioxidant properties are abundant. The consumption of bananas also generally decreases the risk of age-related macular degeneration [33,34].

Free amino acids pattern is typical to a fruit. So it can be used for the analytical characterization of a particular fruit product (Table 3). Various aliphatic and aromatic amines are present in banana. The common amines found in banana are tryptamine (0.03 mg/kg), melatonin (466 ng/kg), methylamine, ethylamine, isobutylamine, isoamylamine, dimethylamine, putrescine, spermidine, ethanolamine, propanolamine, histamine, 2-phenyl-ethylamine, tyramine, dopamine, noradrenaline and serotonin (11.7 mg/kg). Active amines like dopamine are derived from tyramine and serotonin from tryptophan, whose occurrence in these fruits could directly influence their concentrations in human serum [31,33].

The carbohydrate content in banana had been studied. In addition to glucose (3.5% of the edible portion) and fructose (5.7% of the edible portion), monosaccharides occur only in odd amounts. Apart from Saccharose (sucrose- 2.4% of the edible portion), being the dominant oligosaccharide, maltose also occurs in small amounts in banana. 6-Kestose has been identified in ripe bananas. Sugar alcohols like D-Sorbitol are absent in banana since it is a berry. Starch is a building unit of polysaccharides of bananas [37]. It is present in chiefly in unripe berries and its level decreases to a insignificant limit as ripening proceeds. Bananas contain 3% or more of starch content in ripe bananas. The level of lipids molecules is listed in the table below

Carotenoids are present naturally in notable quantities in all fruits and they are the prime factors responsible for the determination of fruit colours[2,3,4]. Bananas are classified as fruits with low carotenoid contents. The distribution pattern of carotenoids could be easily analyzed by HPLC. Various carotenoids are classified based on their structures out of which banana contains beta-carotene (VII) and lutein (IX). Among organic acids malic acids are predominant in berries like bananas and other tropical fruits. They are quantified to be present in 4 milli-equivalents per 100 g of fresh weight of the banana pulp. Almost many fruits are important sources of Vitamin C. Banana contains 7-21 mg/100 g of edible portion. [11,12,13].

As far as aromatic compounds are considered, the distinguishing aromatic compound of bananas is isopentyl acetate. Esters of pentanol, like the esters of acetic, propionic and butyric acids, are also found to contribute to the distinctive aroma of bananas. At the same time the esters of butanol and hexanol with acetic and butyric acids generally are fruitier in character. The aroma of banans could change on heating due to the liberation of glycosidic precursors, oxidation, addition of water and cyclization of individual compounds. A very important contributor to the inclusive, [14,15,16]. soft aroma of the bananas is supposed to be provided by the chemical compounds, eugenol (1), O-methyleugenol (II) and elemicin (III) [17,21,22].

There are two known forms of allergic reaction to banana. The first one caused the birch tree and other pollen allergies is the oral allergy syndrome which is characterized by itching and swelling in the mouth or throat within one hour after consuming the banana fruits. The second form is related to latex allergies which causes urticaria with potentially serious upper gastrointestinal symptoms . The banana fruit also contains high notable levels of biogenic amines such as dopamine and serotonin (Foy and Parratt 1960). The production of dopamine due to the intake of banana fruits also has an allergic effect on the tyrosine-deficit population, (tyrosine is a dopamine precursor present in bananas) . There are no toxins or toxic properties reported in any nutritional study of banana. [22,27].

CONCLUSION

Several studies provided evidence that flesh color can be used to screen for carotenoid-rich banana cultivars.The rich carotenoid content 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 VAD.Additionally, 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. However, in future the recombinant technology has to help the increase carotenoids and micronutrients in the bananas through biofortification to levels which are higher than the current ones.

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Table 1: Chemical composition of banana fruits (Nutritional value per 100g)

Energy	371 kJ (89 kcal)
Carbohydrate	22.84 g
Sugars	12.23 g
Dietary fiber	2.6 g
Fat	0.33 g
Protein	1.09 g
Thiamine (B_1)	(3%) – 0.031 mg
Riboflavin (B_2)	(6%) – 0.073 mg
Niacin (B_3)	(4%) – 0.665 mg
Pantothenic acid (B_5)	(7%) – 0.334 mg
Vitamin (B_6)	(31%) – 0.4 mg
Folate (B_9)	(5%) – 20 μg
Choline	(2%) – 9.8 mg
Vitamin C	(10%) – 8.7 mg
Iron	(2%) – 0.26 mg

Magnesium	(8%) – 27 mg
Manganese	(13%) – 0.27 mg
Phosphorus	(3%) – 22 mg
Potassium	(8%) – 358 mg
Sodium	1 mg
Zinc	(2%) - 0.15 mg
Flouride	2.2 μg

Source: USDA Nutrient Database,Units: μg - micrograms; mg - milligrams; IU – International units

Table 2. Average chemical composition (as % of fresh edible portion)

Dry matter	26.4
Total sugar	20.0
Titratable acidity (citric acid + malic acid + tartaric acid)	0.6
Dietary fiber	1.8
Pectin (expressed as calcium pectate)	0.9
Ash	0.8
pH	4.7

Table 3. Free amino acids in banana fruits (as of % of total free amino acids)

Asp	5-10
Asn	15
Gln	10-15
minobutyric acid	5-10
Histidine	10-15
Pipecolinic acid	5-10

Table 4. Fatty acid composition of bananas (as % of the total fatty acids)

Fatty acids	Banana
14:0	0.6
16:0	58
16:1	8.3
18:0	2.5
18:1	15
18:2	10.6
18:3	3.6

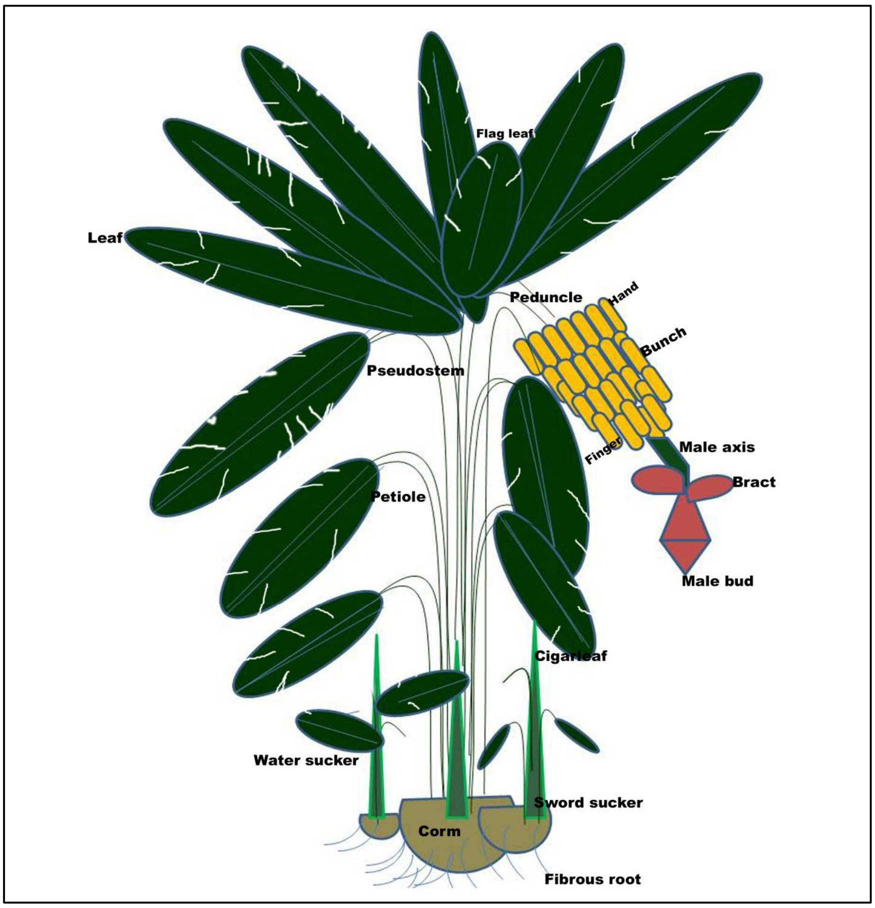

Figure 1.General morphology of banana plant

Figure 2.Banana inflorescence to fruit developmental stage

Figure 3.Commercially important banana cultivars in India.

SNO	Component	Unit	Banana				Plantain	
			Ripe	Unripe	Dried	Flour	Ribe	Unripe
1	Energy	Kcal	89	110	257	340	91	122
2	Water	g	74	69	28	3.0	63	65
3	Protein	g	1.1	1.4	3.0	3.9	0.8	1.3
4	Total lipid	g	0.3	0.2	1.0	1.8	0.1	0.37
5	Carbohydrate	g	21.8	28.7	63.0	82.1	24.3	32
6	Dietary fibre	g	2.0	0.5	5.5	7.6	5.4	2.0-3.4
7	Na	mg	1.0		8.0	3.0		4.0
8	K	mg	385.0		1150.0	1491.0		500
9	Ca	mg	8.0	8	20.0	22.0	7	3.0
10	Mg	mg	30		90.0	108.0	33	35.0
11	P	mg	22		75.0	74.0	35	30.0
12	Fe	mg	0.42	0.9	1.3	1.15	0.5	0.6
13	Cu	mg	0.11		0.4	0.39	0.16	
14	Zn	mg	0.18		0.5	0.61	0.1	
15	Mn	mg	0.2			0.57	15	
16	Eq. b-carotene	mg	68.0	48.3	150.0	183.0	0.03-1.20	390-1035
17	Vitamin E	mg	0.29		0.6			
18	Vitamin C	mg	11.7	31	4.0		20	20
19	Thiamin	mg	0.04	0.04	0.1	0.18	0.05	0.08
20	Riboflavin	mg	0.07	0.02	0.18	0.24	0.05	0.04
21	Niacin	mg	0.61	0.6	2.0	2.8	0.7	0.6
22	Panthotenic acid	mg	0.28				0.37	
23	Vitamin B6	mg	0.47					
24	Total Folate	mg	23.0				0.016	
25	Biotin	mg	2.6					
26	Isoleucine	mg	34.0			167.0		
27	Leucine	mg	71.0			359.0		
28	Lysine	mg	50.0			162.0		
29	Methionine	mg	14.0			74.0		
30	Cystine	mg	20.0			63.0		
31	Phenylalanine	mg	41.0			201.0		
32	Tyrosine	mg	26.0			121.0		
33	Threonine	mg	36.0			171.0		
34	Tryptophan	mg	13.0					
35	Valine	mg	49.0			282.0		
36	Arginine	mg	57.0			176.0		
37	Histidine	mg	86.0			333.0		
38	Alanine	mg	43.0			222.0		
39	Aspartic acid	mg	120.0			503.0		
40	Glutamic Acid	mg	115.0			399.0		
41	Glycine	mg	41.0			190.0		
42	Proline	mg	43.0			229.0		
43	Serine	mg	49.0			226.0		
44	Dopamine	mg	65.0					
45	Serotonine	mg	3.3				45	76
46	Thiamine	mg	0.7					
47	Malic acid	meq	6.20	1.36				
48	Citric acid	meq	2.17	0.68				
49	Oxalic acid	meq	1.37	2.33				
50	Other acids	meq	0.17	0.19				

Reference:

1 Anonymous (1981).
2 Marriott and Lancaster (1983).
3 Woolfe (1992).
4 Ciqua Cneva (1993).
5 Lassoudie`re (2007).
6 Guyle`ne Aurore (2009).

Figure 4.Chemical composition and biochemical features of banana and plantain at different physiological stages, and after transformation, per 100 g of fresh weight