RESEARCH ARTICLE

Biochemical and nutritional characteristics of some commercial banana (*Musa* spp.) cultivars of Kerala

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Abstract

Biochemical and nutritional traits of 6 banana (*Musa* spp.) cultivars commercially cultivated in Kerala, belonging to different genomic groups *viz.* Pisang Lilin (AA), Grand Naine (ABB), Nendran (AAB), Karpooravalli (ABB), Njalipoovan (AB) and Yangambi (KM-5) (AAA) were evaluated. Biochemical and nutritional characters on variables such as titratable acidity (%), total soluble solids (°Brix) (TSS), total protein (g), total carbohydrates (g), total fat (%), total ash (%), crude fibre (%), vitamin C (mg), calcium (mg), potassium (mg), total phenols (mg) and total carotenoid (µg) content were laid out in a completely randomized design and subjected to one way ANOVA to determine the significance (*p*=.05). The cultivar Nendran (AAB) exhibited desirable biochemical and nutritional traits, particularly for titratable acidity (0.34%), TSS (23.90°B), total carbohydrates (37.51g/100g), total ash (14.89%) and crude fibre (0.90%) content. Yangambi (KM-5) (AAA) exhibited the highest values for major minerals of banana, especially calcium (168.90 mg/100g) and potassium (406.60 mg/100g). The current study reveals biochemical and nutritional variation among banana cultivars from different genomic groups, with similarities and differences overlapping even among banana cultivars from the same genomic group.

Keywords

genomic group, cultivars, biochemical characterization, nutritional characterization

Introduction

Banana (*Musa spp.*) is the most important staple crop in the world, which is affordable to many households and has a good source of nutrients (1). The crop is grown in the world's tropical and subtropical regions and belongs to the family Musaceae of the Zingiberales order. Over a thousand banana cultivars or landraces have been identified, all of which contribute significantly to the commercial and nutritional value of bananas for millions of people worldwide (2). The majority of bananas in the wild are subjected to widespread exploitation and destruction, which has resulted in their extinction in their native habitat. Furthermore, the diversity of bananas (*Musa* spp*.)* in different places makes it difficult to identify and classify banana varieties correctly (3). A nomenclature scheme for edible cultivated bananas have been developed that is based on ploidy level and morphological features to describe edible cultivated bananas in order to reduce confusion (4). The modern edible banana is the result of interspecific and intraspecific hybridization between two wild species, *Musa acuminata* (AA) and *Musa balbisiana* (BB), both of which are thought to impart distinctive qualities to banana

fruits such as colour and appearance, flavour, texture and nutritional value (1, 5). India subcontinent is a center of variety for the modern cultivated bananas, particularly AA, AB, AAA, AAB and ABB clones, accounting for 25 % of global production at 31747000 metric tonnes in an area of 898, 000 ha (6, 7). The majority of the bananas cultivated in India are from the southern part of the subcontinent, which is believed to be the home of both the wild and cultivated forms. Kerala, a state in southern India, has diverse agroclimatic conditions and genetic diversity of banana, with the plant thriving in both wild and cultivated forms. The state has the largest area under production at 52810.61 ha and a production of 424908.07 metric tonnes (7). Despite its rich genetic diversity and diverse agro-climatic conditions, only a small number of banana cultivars are commercially grown (8). Kerala cultivars of commercial importance include Red Banana, Njalipoovan, Nendran, Palayankodan, Rasthali, Monthan, Karpooravalli and Robusta (9, 10). Nendran is popular for its large fruits, with thick peel having sweet and distinctive flavour, while Njalipoovan is popular for its sweet and soft pulp and less susceptibility to pest and diseases. In the case of Karpooravalli, this variety is believed to be the sweetest among Indian banana cultivars and it is admired for its pleasant flavour with good keeping quality. Grand Naine variety is gaining popularity and it is most preferred due to its good quality bunches with fruits that develop into a beautiful yellow colour with better shelf life (9, 10). Yangambi (KM-5) is a newly introduced banana variety to Kerala, which has growth and yield that are comparable to the local banana cultivars with sub-acid flavour. Pisang Lilin is a soft and sweet diploid dessert banana that is normally used as male/female parent in hybridization programmes (11). The vast genetic variety of banana germplasm necessitates addressing the features that operate as a medium for improving quality parameters such as fruit identity, customer preferences and nutrition (8). Few studies have been conducted to compare the biochemical and nutritional characteristics of different banana genomic groups. The current study's goal is to evaluate and investigate banana cultivars from different genomic groups in order to uncover their biochemical and nutritional characteristics.

Materials and Methods

The study was carried out at the Department of Post Harvest Technology, College of Agriculture, Vellanikkara in Thrissur district of Kerala, between December 2020 and March 2021, with 6 banana (*Musa* spp.) cultivars from different genomic groups. The Simmonds and Shepherd (3) nomenclature scheme, which is based on ploidy and morphological characteristics, was used to identify the genomic groups of 6 cultivars namely Nendran (AAB), Karpooravalli (ABB), Njalipoovan (AB), Pisang Lilin (AA), Grand Naine (AAA) and Yangambi (KM-5) (AAA). The fruits of the respective cultivars were collected from the Banana Research Station, Kannara in Thrissur district of Kerala, where they were grown under uniform conditions in accordance with the recommendations of the Kerala Agricultural University's Package of Practices (12).

Fruit biochemical and nutritional characterisation

Firm ripe banana fruits were analysed for different biochemical and nutritional parameters which included titratable acidity (TA), total soluble solid (TSS) content, total protein, total carbohydrates, total fat, total ash, crude fibre, vitamin C, calcium (Ca), potassium (K) and total carotenoid content which were determined using standard methods (13). Total phenol content was determined by following the procedure described (14).

Determination of titratable acidity

Titratable acidity was estimated by titrating known volume of sample against standard 0.1N NaOH using phenolphthalein as an indicator and expressed as % of malic acid.

Determination of total soluble solid content

Total soluble solid content was assessed using Erma hand refractometer (range 0-32°Brix) and expressed in degree Brix.

Determination of total protein

Total protein was estimated by Lowry method where proteins are exhibited by blue colour change in the presence of Folin-Ciocalteau reagent and readings were taken at 660 nm using a spectrophotometer (UV-Visible 1800 spectrophotometer, Shimadzhu, Kyoto, Japan). The quantification of total protein was done using a calibration curve prepared and results were expressed as g per 100 g of sample.

Determination of total carbohydrates

The total carbohydrate were estimated using the Anthrone method (13) where 100 mg of sample was hydrolysed using 2.5N HCL and mixed with anthrone reagent to form a green compound and the reading was measured at 630 nm (UV-Visible 1800 spectrophotometer, Shimadzhu, Kyoto, Japan). The carbohydrates readings were calculated from the plotted standard graph and expressed as g of glucose per 100 g fruit.

Total fat content

The total fat content was determined by soxhlet extraction method with petroleum ether as solvent at temperatures of 60-80 °C for 6 hrs without interruption. The obtained extract was allowed to cool, evaporate and the weight recorded to a constant value in %.

Estimation of total ash

The total ash was determined by the change in mass after ashing in a muffle furnace at 600 °C. The total ash was calculated by the difference in weight and expressed in %.

Crude fiber estimation

The crude fiber was determined used an acid-base extraction approach using by first extracting with sulphuric acid (0.26N) and subsequently sodium hydroxide (0.31N) treatment of a previously dried sample. The solvent was then filtered and the residue that was obtained was weighed, incinerated at temperatures of 130 °C, coded and weighed again. The loss in weight was given as crude fiber content and expressed in %.

Vitamin C determination

The vitamin C content was determined by taking 5 g of the sample and extracting it in 4 % oxalic acid. Vitamin C content of the pulp was estimated by using standard indicator dye 2, 6, dicholorophenol indophenol and expressed as mg/100 g of fruit.

Calcium and potassium determination

Calcium and potassium were determined by measuring sample ash solution composed of 1 mole HCL and distilled water against the standard solutions of Ca and K using flame photometer and the results were expressed in mg/100 g.

Total carotenoids determination

Total carotenoids were extracted with acetone and petroleum ether in a separating funnel, the anhydrous sodium sulphate was used to absorb excess moisture during extraction. Acetone (3%) was used as blank and optical density of the collected extract was measured at 452 nm (UV-Visible 1800 spectrophotometer, Shimadzhu, Kyoto, Japan) and the quantified results were expressed as µg/100 g.

Total phenol estimation

Total phenol content was determined by mixing a properly diluted banana pulp extract with Folin-Ciocalteau reagent to form a blue coloured complex and readings were taken at 740 nm using a spectrophotometer (UV-Visible 1800 spectrophotometer, Shimadzhu, Kyoto, Japan).The quantification of total phenolic contents was used using a calibration curve prepared and results were expressed as mg catechol equivalent per 100 g of sample.

Data analysis

The experiment was laid out in a completely randomised design with three replications and presented as means in one way ANOVA to examine significant differences using the Web Based Agricultural Statistics Software Package (WASP). Duncan's multiple range test was used to compare means at a 95% confidence level (p=.05).

Results and Discussion

Table 1 displays the biochemical and nutritional composition of banana fruits from various genomic groups. In this study, no significant difference was observed in the titratable acidity among bananas cultivars of different genomic groups. However, triploid banana cultivars recorded higher titratable acidity compared to the diploid cultivars. The study proved that diploid banana cultivars, particularly Pisang Lilin (AA) was more acidic than the triploids at ripening stage. The accumulation of organic acids, primarily malic acid, as a result of fruit ripening may be associated with acidity in the pulp of 6 banana cultivars from different genomic groups.

Significant difference in the total soluble solid content was observed among the 6 banana cultivars, with Nendran (AAB) showing the highest value of 23.90°Brix while the lowest was in Njalipoovan (AB) at 16.43°Brix. Significant difference in total soluble solid content was not observed among Karpooravalli (ABB), Pisang Lilin (AA), Grand Naine (AAA) and Yangambi (KM-5) (AAA) which ranged from 18.33-21.33°Brix. The study also revealed that total soluble solid content was positively correlated to total carbohydrate content in banana. The existence of direct relationship between total soluble solids and carbohydrates could be seen in the banana cultivars studied, as Nendran (AAB) had the highest total soluble solid content (23.90°Brix), it also had the highest carbohydrate content (37.51 g/100 g). Likewise, Njalipoovan (AB) having the least values of total soluble solid content (16.43°Brix) had the lowest total carbohydrate content of 25.67 g/100 g. Total proteins and total fats had no significant differences, with values ranging from 1.84–2.72 g/100 g and 0.13–0.41% respectively. The present results are in agreement with the previous research results where protein and fat content ranging between 1-2.5% and 1% was noticed. Also, compounds are supposed to vary depending upon the genome type, variety, physiological stage of the fruit, environmental conditions and altitude (15, 16).

Total ash is the amount of inorganic matter of the fruit. Triploids with plantain genome 'B' *i.e.,* Nendran (AAB) and Karpooravalli (ABB) had a significantly (p=.05) higher total ash content compared to the triploid cultivars of Grand Naine (AAA) and Yangambi (KM-5) (AAA) which are dominated by 'A' of dessert banana (Table I). The diploids Pisang Lilin (AA) and Njalipoovan (AB) showed intermediate values between triploids of 'A' and that of 'B' with regard

Table 1. Biochemical and nutritional characteristics of some commercial banana (*Musa spp*.) cultivars of Kerala

Cultivars	TA (%)	TSS (°Brix)	Total protein (g/100g)	Total carbo-hydrate (g/100g)	Total fat (%)	Total ash (%)	Crude fibre (%)	Vit. C (mg/100g)	Ca (mg/100g)	K (mg/100g)	Fe (mg/100g)
Nendran	0.34	23.90[a]	2.31	37.51	0.31	14.89[a]	0.90	12.57[a]	82.50[b]	237.67[bc]	0.67
Pisang Lilin	0.18	21.67[ab]	1.67	26.00	0.38	6.01[c]	0.17	13.33[a]	92.50[b]	346.80[ab]	0.84
Karpooravalli	0.27	21.33[ab]	2.32	33.87	0.13	9.30[b]	0.69	17.33[a]	101.10[b]	335.33[ab]	0.54
Njalipoovan	0.22	16.43[c]	2.09	25.67	0.41	3.67[d]	0.49	13.33[a]	90.30[b]	260.73[bc]	0.89
Grand Naine	0.29	21.53[ab]	2.72	24.70	0.36	1.16[e]	0.36	10.67[a]	69.90[b]	187.27[c]	0.53
Yangambi	0.31	18.33[bc]	1.84	31.33	0.26	2.68[de]	0.48	8.00[a]	168.90[a]	406.60[a]	0.40
S.Em (±)	0.03	0.81	0.39	2.05	0.07	0.29	0.12	1.31	5.86	24.83	0.08
CD	NS	4.34	NS	NS	NS	2.15	NS	NS	43.04	132.55	NS

TA= Titratable acidity; TSS=Total soluble solids; Vit. C=Vitamin C; Ca=Calcium; K=Potassium; Fe=Iron

to the total ash content. The high ash content in triploid banana cultivars with a 'B' genome composition corresponds to a high mineral content compared to the banana dominated by 'A' genome where the ash content was lower (17). The diploid cultivars irrespective of their genomic composition were observed to have intermediary values with respect to ash content. Triploid banana cultivars dominated by 'A' genome with lower total ash content can be used for purposes other than cooking.

Crude fibre is an important dietary component with a variety of health benefits, including the maintenance of healthy laxation and a lower risk of heart disease and cancer. No significant difference was found in the crude fibre content among the 6 banana cultivars studied, however, the highest value of crude fibre was found in Nendran (AAB) at 0.90 % and the least in Pisang Lilin (AA) at 0.17 %. The results revealed that triploids having 'B' genome had higher crude fibre than the cultivars with dominant 'A' genome. Crude fiber results were similar to those reported in previous works (18).

No significant difference was found among the 6 banana cultivars studied however the highest values vitamin C values were in Karpooravalli (ABB) at 17.33 mg/100 g and the lowest in Yangambi (KM-5) (AAA) at 8.00 mg/100 g. The results revealed that banana cultivars having more 'B' genome had higher vitamin C than those with dominant 'A' genome. The results are in consistent with those reported by other authors who similarly reported high ascorbic acid in banana cultivars having the presence of 'B' genomic group (19, 20) Adults need 90 mg of vitamin C per day, and the bananas used in this study can supply 8.88-19.25 % of that amount to supplement the diet and boost the body's resistance to diseases like coronavirus disease 2019 (COVID-19) (21).

Calcium and potassium are the most abundant minerals that are found in banana. A significant difference was found in calcium content between the cultivars, the highest value was recorded in Yangambi (KM-5) (AAA) at 168.90 mg/100 g and the lowest in Grand Naine (AAA) at 69.90 mg/100 g. The difference in biochemical composition within the same genomic group can be attributed to differences in sub-groups, Yangambi (KM-5) (AAA) belongs to Ibota which has a close association to the plantain group, which is more nutritious than other dessert bananas (18, 19 22, 23). Banana cultivars with a close association with the 'B' genome were found to have more calcium than cultivars with a strong association with the 'A' genome, which was consistent with the findings of the current study (24). The calcium content ranges are consistent with the values reported in the banana literature (23, 25).

Yangambi (KM-5) (AAA) also recorded the highest values of potassium at 406.60 mg/100 g and the lowest was in Grand Naine (AAA) at 187.27 mg/100 g. The average adult's daily adequate potassium intake is 4700 mg, so 100 g of Yangambi (KM-5) and Grand Naine (AAA) banana pulp would provide 8.65 and 1.49 % of the K requirement respectively (26). Yangambi (KM-5) is more nutritious than the other dessert cultivars due to its relationship with the

plantain group, which causes it to exhibit characteristics more similar to the *M. balbisiana* group than to *M. acuminata*. The potassium content ranges correspond to those reported in the banana literature (18, 25, 27).

Iron content recorded for banana cultivars in different genomic group revealed no significant difference (Table I). However, Njalipoovan (AB) had a higher iron content of 0.89 mg/100 g, while the lowest was in Yangambi (KM-5) (AAA) at 0.4 mg/100 g. Iron, a mineral vital for the proper functioning of haemoglobin has the potential to alleviate micro-nutrient deficiency in human diet. This mineral represents up to 2 % of total weight at the ripening stage of the fruit which conforms to the present study (28, 29).

Total phenols

The total phenol obtained from pulp of banana fruits of different genomic groups are presented in Fig. I. Significant variation in the total phenols, expressed as catechol
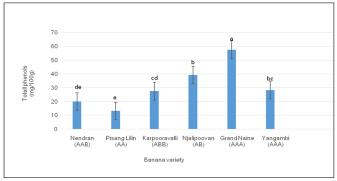

Fig. 1. Total phenol content in the pulp of some commercial banana (*Musa* spp.) cultivars of Kerala.

equivalents was recorded among the cultivars. The highest phenol content was observed in Grand Naine (AAA) at 57.5 mg/100 g, almost twice the amount of Njalipoovan (AB) which had 39.17 mg/100 g. Non-significant variation was observed in the total phenol content of cultivars of Yangambi (KM-5) (AAA) and Karpooravalli (ABB) which had 32.50 and 27.50 mg/100 g respectively. The lowest total phenol content was recorded in Nendran (AAB) and Pisang Lilin (AA) which recorded 20 and 13.2 mg/100 g respectively. Banana cultivars with the *M. balbisiana* genome, such as Nendran, have been found to have a high total phenol content, whereas another study discovered that the triploid 'Highgate' banana cultivar with a AAA genome has the highest total phenol content when compared to other cultivars from different genomic groups (30, 31). *Musa* spp. has a sufficiently high degree of variability in total phenol content due to variations in antioxidants such as the carotenoids and flavonoid content, which is a positive factor in the selection for functional food development (26). Variations in the total phenol content among different banana cultivars in the present study can be attributed to differences in genotype and environmental factors which have a very significant role in biochemical constituents. Similar findings were reported by other authors (26, 32). However, some other authors reported total phenols content in the range of 0.05-76.37 mg/g, expressed as gallic acid equivalents (26, 33).

Total carotenoids

Total carotenoid content of banana pulp revealed significant difference among the 6 banana cultivars (Fig. 2). The
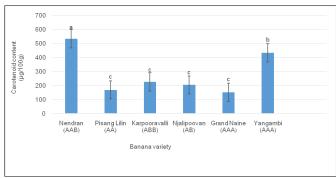

Fig. 2. Total carotenoid content in the pulp of some commercial banana (*Musa* spp*.*) cultivars of Kerala.

level of carotenoids was highest (533.35 µg/100 g) in Nendran (AAB), followed by Yangambi (KM-5) (AAA) (433.27 µg/100 g). No significant difference was recorded among the other cultivars. However, Grand Naine (AAA) had the lowest carotenoid value among all the six banana cultivars which recorded 151.50 µg/100 g. Similar studies confirm that the total carotenoid content in banana was in the range of 4.7-10.0 µg/g and that the genomic group AAB of Nendran had the maximum carotenoid content (26, 27). Carotenoids, characterised by yellow/orange colouration, is an important precursor of vitamin A, essential for prevention of chronic diseases. The recommended daily allowance for vitamin A ranges from 400-900 µg equivalent per day among children up to 18 years. Nendran (AAB) and Yangambi (KM-5) (AAA) are good cultivars for including in children's food to reduce the incidence of diseases associated with vitamin A deficiency, such as eye and vision problems, cellular differentiation and humoral and cell-mediated immune system functionality (34).

Based on the present study, it can be interpreted that an increase in ploidy level will amplify the biochemical traits. In some cases, polyploidy may affect key genes involved in developmental pathways and result in the expression of deleterious alleles associated with poor biochemical and nutritional traits (35). However, the current study found that each banana variety had industrial potential, with Nendran (AAB) being the best of the 6 banana cultivars chosen from different genomic groups in terms of biochemical and nutritional traits.

Conclusion

The findings of this study show significant biochemical and nutritional heterogeneity among banana cultivars from different genomic groups, with similarities and differences overlapping even among cultivars from the same genomic group. The cultivar Nendran (AAB) exhibited desirable biochemical and nutritional traits such as titratable acidity, total soluble solids, total carbohydrates, total ash and crude fibre content. Despite the fact that Grand Naine (AAA) and Yangambi (KM-5) (AAA) belonged to the same genomic group, the 2 cultivars had significant differences in biochemical and nutritional characteristics. Major min-

erals such as calcium and potassium were more abundant in Yangambi (KM-5) (AAA) than other dessert banana cultivars. To lower the occurrence of disorders related with vitamin A deficiency, cultivars such as Nendran (AAB) and Yangambi (KM-5) (AAA) should be added to the diet, particularly in children's food. These findings could help food processors choose suitable banana cultivars for industrial purposes, such as functional foods and for a specific target group.

Authors contributions

The work was part of the first author's Ph D thesis, which was supervised by the second and third authors. The final manuscript has been read and approved by all authors.

Compliance with ethical standards

Conflict of interest: Compliance with ethical standards is not applicable to the present study.

Ethical issues: None.

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