Evaluation of the Nutritional Value of Selected Banana Varieties Grown in Sri Lanka

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Abstract: There are nearly 30 varieties of banana (*Musa spp.*) are grown in Sri Lanka. Some of them are indigenous while the others are exotic. In the present study, five banana varieties commonly grown in Sri Lanka, namely *Seeni kesel*, *Ambul kesel*, *Kolikuttu*, *Rathambala* and *Puwalu* were evaluated for their nutritional composition. Samples of each banana variety were collected from different geographical locations of the country representing all agro-climatic zones. Healthy and undamaged fruits were collected, cleaned and air dried at 45 °C, pooled and stored at 4 °C for further analysis. Proximate and mineral composition of each sample were determined and presented on fresh weight basis. Moisture, ash, crude fat, crude protein and total carbohydrate contents were determined using AOAC methods. The moisture content ranged between 67.24±2.19 and 73.14±0.56% while the crude protein content ranged between 1.20±0.02 and 1.41±0.04%. The corresponding ranges for ash, total carbohydrates and crude fat were 1.18±0.05 - 3.89±0.38%, 13.46±0.36 - 26.46±0.36% and 0.14±0.00 - 0.20±0.02%, respectively. All varieties of banana contained Ca, Mg, K, Na, Fe, Ba, Zn, Mn, Cu, Sr, Rb and Al in considerable quantities while Cr, Co, Ni, Se, Mo, V, Ga, Cd, Bi, As, Li and Be were detected in minute quantities. Comparatively, *Seeni kesel* was found to be the superior ($p<0.05$) source of essential mineral elements. Among highly concerned heavy metals, the highest Cr and Cd contents ($p<0.05$) were found in *Seeni kesel* while *Puwalu* contained the highest As content, which might be resulted by malpractices of cultivation, artificial ripening, packaging and storage.

Keywords: Crude fat, crude protein, mineral composition, proximate composition

Introduction

Diets rich in fruits have historically held a fundamental place in dietary guidance as a consequence of their concentrated amounts of vitamins, especially vitamins C and A, minerals, such as calcium, magnesium, iron and phosphorus and phytochemicals, particularly antioxidants. Intake of fruits and vegetables is an important indicator of diet quality and protective factors against certain chronic diseases such as cardiovascular disease, cancer, diabetes, Alzheimer disease, cataracts, and age-related functional decline (Willett, 1995; Temple, 2000).

Analysis of nutritional composition of food is crucial to provide nutrient data at that same aggregate level, and strive for year-round, nation-wide mean values, with all compositional differences related to agro-ecological zone, seasonality and biodiversity. Through compositional analysis, knowledge on the differences in nutritional value among fruits from different species and from varieties of the same species can be given to the professionals in health, nutrition, agriculture and environment for not misleading them in diet planning, food consumption surveys, nutrition and health policies and programs, agricultural policies and programs, etc. Recent data on nutritional value of Sri Lankan banana varieties are very scanty thus the importances of comparative analysis and reporting the composition of them have been a long felt need. Through compositional analysis, nutritionally more important varieties among others can be investigated. It is one of the vital type of studies

since, intra-specific differences of fruits can be used as the base in mediating nutrient deficiency, nutrient adequacy and nutrient toxicity of a population in a country.

Banana (*Musa* spp.) is native to Southeast and South Asia and it is the most widely cultivated and consumed fruit in Sri Lanka. Moreover, it is the mostly produced and traded fruit in fresh form in the world. The wide variation in temperature, rainfall, topography and soils in Sri Lanka has offered a wide diversity of ecosystems resulting in a rich diversity of plant species throughout all agro-climatic zones. Consequently, Sri Lanka is encompasses 29 banana cultivars and two wild varieties. Among total land area under numerous fruit cultivations in Sri Lanka, banana claims 69 – 70% (Ekanayake *et al.* 2001).

Materials and Methods

Sample Collection and Preparation

A total of 500 g of healthy, undamaged fruits of five banana varieties (*Seeni kesel*, *Ambul kesel*, *Kolikuttu*, *Rathambala* and *Puwalu*) were collected from seven agro-climatic zones of Sri Lanka separately, packed in polythene bags, labeled, placed in temperature controlled containers and transported to the laboratory without a delay.

Figure 1 Ambul kesel variety

Figure 2 Seeni kesel variety

Figure 3 Kolikuttu variety

Figure 4 Rathambala variety

Figure 5 Puwalu variety

The samples were photographed, identified and authenticated by taxonomists in the Plant Genetic Resources Centre, Sri Lanka. They were sorted, cleaned appropriately and oven dried at 45 °C (Phoenix[™], Germany). The oven dried samples from each agro-climatic zone were disintegrated in a stainless steel grinder (Apex[™], India), pooled separately in similar quantities and homogenized assuring uniform distribution to prepare the working samples. Oven dried samples were stored at 4 °C (LG[™], Japan) for further analyses.

Proximate Analysis

Moisture content of fresh samples and crude protein, fat and ash contents of oven dried samples were determined according to the AOAC (2000). The crude protein and crude fat contents were determined using Kjeldahl method (Digester - VELP Scientifica[™], DK 6, Italy and Distillation unit - VELP Scientifica[™], UDK 129, Italy) and soxhlet extraction methods respectively. The moisture content was determined by drying the sample to a constant weight at 105 °C in a forced air-oven (SIBATA[™], SPF-600, Japan). The ash content was determined using weight loss method by muffle furnace (HOBERSAL[™], HP-150, Spain). All chemicals used (petroleum ether, potassium sulfate, copper sulfate, boric acid, sulphuric acid, sodium hydroxide, bromocresol green and methyl red mixed indicator, hydrochloric acid and Devarda's alloy) were of analytical grade purchased from Sigma-Aldrich[™], USA.

Determination of Total Carbohydrate Content

The total carbohydrate content was determined according to the method described in AACC 2003 (American Association of Cereal Chemists). A sample (100 mg) was acid-hydrolyzed in a boiling water bath for three hours with 5 mL of 2.5 N HCl. Then the sample was cooled to room temperature, neutralized with sodium carbonate until the effervescence ceased, made up the volume to 100 mL and centrifuged at 4000 rpm for 10 minutes. A sample (0.1 mL) of the supernatant collected was pipetted out and volume was made up to 1 mL with distilled water. Blank was set with 1 mL of distilled water. Five percent Phenol solution (1 mL) and 5 mL of 96% sulphuric acid were added into each tube, the contents were shaken for 10 minutes and placed in a water bath at 25 – 30 °C for 20 min. All analyses were carried out in triplicates and absorbance was taken using UV/Visible microplate spectrophotometer (Thermo Scientific[™], Genesys 10S, UK) at 490 nm. Total carbohydrate contents were calculated as percentages using the glucose standard calibration curve (0.0028-0.0143 ppm). Absorbance of the blank was taken and necessary corrections were made in calculations. All chemical reagents used were of analytical grade and purchased from Sigma-Aldrich[™], USA.

Quantification of the Mineral Content

Mineral analysis by ICP-MS was performed according to the method described by de la Rocha (2009) with some minor modifications. Acid digestion of the oven dried samples (0.2 g) was performed with 10 mL of nitric acid (65% w/v) using a commercial high-pressure laboratory microwave oven (CEMTM Corporation, BR601050, USA), operating by setting the program for 15 min ramping time, 10 min holding time during digestion at 180 °C and 15 min cooling time. Digested samples were transferred to a 50 mL volumetric flask, made up to volume with de-ionized water, filtered and stored at 4 °C. Test solutions contained 100 µg/L of Rh and Re, which were used as internal standards to correct instrumental drift and possible matrix effects.

For calibration, multi-elemental standard solutions were prepared with the following concentrations: 0, 5, 10, 30 and 50 mg/L for Na, Mg, K, Al, Mn, Zn, Fe, Rb, Sr and Ba; and 0, 0.8, 3.0 and 10.0, 20.0 µg/L for Cr, Co, Ni, Cu, As, Se, Li, Be, V, Ga, Mo, Cd and Bi. Analysis was carried out in triplicates. Inductively Coupled Plasma Mass Spectrometer (iCAPQ, Thermo Scientific, UK) was used for analytical determinations. Operating conditions of the ICP-MS for the analysis of the leafy vegetable samples are shown in Table 1. All analytical grade chemical reagents and multi-elemental standards used were purchased from Sigma-AldrichTM, USA.

Table 1 Operating conditions for ICP Mass Spectrometer

Parameter	Value
Auto Sampler	CETAC ASX-560
Plasma power	1550 W
Cool gas flow	14 L/min
Auxiliary gas flow	0.65 L/min
Sample cone	Nickel, 1 mm orifice diameter
Skimmer cone diameter	Nickel, 0.75 mm orifice
Dwell time	10 ms (40 ms for Se, As)
RSD (3 replicates) typical	< 1%
Sample flow	0.4 mL/min
LOD typical	< 0.1 ppb

Elements with the highest isotopic abundance were selected as analytical mass. For the within-run assessment, the accuracy and precision of the assays were examined in a single run, with six replicate samples. For the between-run assessment, TM 25.4 (Environment Canada) for water was analyzed as certified reference material which covered the range of the elements studied such as Al, Cr, Mn, Co, Ni, Cu, Zn, As, and Se in six separate runs. Accuracy was defined as the percentage difference between the monitored concentration and the expected value (%D). Precision was expressed as the percentage of the variation coefficient (%CV). Acceptance criteria

for accuracy and precision, derived from ICH (1996) rules, were as follows: the mean %D and %CV should not exceed $\pm 15\%$; 75% of all samples had to be within $\pm 15\%$ of expected concentrations. In the experiment, no more than one of the six samples within a given concentration could exceed $\pm 15\%$ of their expected values.

Statistical Analysis

Data for all determinations were subjected to analysis of variance (ANOVA). Complete Randomized Design (CRD) was used as the experimental model and means of experimental data were compared by Duncan's multiple range test ($p < 0.05$). Statistical analyses were conducted using the SAS Statistical Analysis System SAS/IML 14.1 (SAS Institute Inc., Cary, NC).

Results and Discussion

Names of banana varieties have been abbreviated as follows for the convenience of stating; *Seeni kesel* – SK, *Ambul kesel* – AK, *Kolikuttu* – KK, *Rathambala* – RT, and *Puwalu* – PU. Moisture contents were significantly higher in AK, KK, and RT than in PU and SK in decreasing order ($p < 0.05$). Crude protein contents of SK and KK were significantly higher than that of RT, AK and PU in decreasing order ($p < 0.05$).

SK was comprised of the highest ash content followed in decreasing order by AK, KK, RT, and PU ($p < 0.05$). PU and SK were contained higher crude fat contents than in KK, AK and RT in decreasing order ($p < 0.05$). SK was comprised of the highest total carbohydrate content followed in decreasing order by PU, KK, RT and AK ($p < 0.05$). The values obtained from this study in comparison to those available in literature showed somewhat higher values for ash contents, fairly lower values for crude fat contents and similar values for moisture and total carbohydrate contents with that reported by Hettiaratchi *et al.* (2011) who analyzed *Kolikuttu*, *Seeni kesel* and *Embul kesel* varieties. Deraniyagala *et al.* (1994) determined total carbohydrate contents of *Kolikuttu*, *Anamalu* and *Embul kesel* varieties resulting somewhat higher values than the present study.

These dissimilarities in nutritional composition among various studies may be come up due to the differences in farming practices, established environmental conditions and age of plants at harvest which affects their genetic composition. Recommended Dietary Allowance (RDA) of macronutrients can be compared with macronutrient contents of banana assuming complete digestion and absorption. RDA of total digestible carbohydrates for a person aged 19 to above 70 years is 130 g per day according to Institute of Medicine, US (2005) and the requirement could be met solely by intake of about 491 g, 966 g, 569 g, 964 g and 524 g of SK or AK or KK or RT or PU varieties respectively per day assuming complete digestion and absorption. RDA of protein for a male aged 19 to above 70 years is 56 g per day while 46 g per day is for a female aged 19 to above 70 years (Institute of Medicine, US, 2005) and intake of 3 - 5 kg of studied banana varieties might complete the daily protein requirement solely which may indicate the low protein content of banana. According to The United States Department of Agriculture (USDA), if a person eats a diet of 2,000 calories per day, 44 - 77 g of total fat should be ingested daily. When compared with that recommendation, banana was obvious to be a poor source of fat.

Table 2 Proximate composition (%) of selected banana varieties on fresh weight basis

Banana Varieties	Moisture	Crude protein	Crude fat	Ash	Total Carbohydrate
SK	67.24 $\pm$ 2.19 ^c	1.36 $\pm$ 0.04 ^a	0.18 $\pm$ 0.00 ^a	3.89 $\pm$ 0.38 ^a	26.46 $\pm$ 0.36 ^a
AK	73.00 $\pm$ 1.66 ^a	1.22 $\pm$ 0.00 ^{bc}	0.14 $\pm$ 0.00 ^b	1.43 $\pm$ 0.02 ^b	13.46 $\pm$ 0.36 ^c
KK	72.06 $\pm$ 2.33 ^a	1.41 $\pm$ 0.04 ^a	0.17 $\pm$ 0.01 ^{ab}	1.42 $\pm$ 0.11 ^b	22.86 $\pm$ 0.34 ^b
RT	73.14 $\pm$ 0.56 ^a	1.34 $\pm$ 0.09 ^{ab}	0.14 $\pm$ 0.00 ^b	1.41 $\pm$ 0.03 ^b	13.49 $\pm$ 1.41 ^c
PU	70.21 $\pm$ 0.38 ^b	1.20 $\pm$ 0.02 ^b	0.20 $\pm$ 0.02 ^a	1.18 $\pm$ 0.05 ^b	24.82 $\pm$ 0.89 ^{ab}

Data represent the mean values $\pm$ SD ($n=3$) of three independent experiments. Means followed by the same letters in a column are not significantly different at $p<0.05$ level by Duncan's multiple range test.

According to the mineral analysis, SK contained the highest amounts of Mn, Fe, Cu, Sr, Ba, Cr, Co, Ni, Se, Be, Ga, Mo and Cd ($p<0.05$). AK was encompassed of the highest amounts of Al, Zn, Rb and Li in contrast to the lowest amount of Na, Se and Be it contained ($p<0.05$). The highest amounts of Na as well as the lowest amounts of Mn, Rb, Cu and Cr were found in KK ($p<0.05$). RT was comprised of the highest quantities of Mg, K, V and Bi whilst it contained the lowest amounts of Ca, Zn, Sr, Ba, Co, As, Li and Mo ($p<0.05$).

PU was resulted with the highest amounts of Ca and As plus the lowest amounts of Mg, K, Fe, Ni, V, Ga and Cd. Minerals, though they are macro or micro-minerals required in the body for the maintenance of physiochemical processes essential to life. While minerals like K, Mg, Ca, Zn, Fe and Cu are considered essential, heavy metals like Pb, Cd, Cr, As, Hg and Sn are considered as a toxic contaminant and evidence of their requirements and necessities for the body is weak (Sobukola *et al*, 2010). As reported by Banadda *et al.* (2011), Pb and Cd which are residues from the polymerization process of polythene can migrate at high temperature and under long ripening and storage period. Since chemical ripening agents like carbide are used to generate heat, the high temperature needed for the heavy metals to migrate is provided (Ajayi and Mbah, 2007).

Calcium carbide treatment in fruit ripening is extremely hazardous because it contains traces of As and P, and once dissolved in water, it produces acetylene gas. As, P and acetylene gas may affect the different body organs and causes various health problems like headache, dizziness, mood disturbances, sleepiness, mental confusion, memory loss, cerebral edema, seizures and prolonged hypoxia (Asif, 2012). As shown in the Figure 6, significantly higher As content was observed in PU and moderate amounts of As were observed in SK, AK and KK ($p<0.05$) indicating potential excess carbide usage. Moreover, the highest Cd and Cr contents were found in SK while AK, KK and RT contained moderate amounts which were not significantly different ($p<0.05$) pointing out a possible heavy metal contaminations during the artificial ripening attempts.

Figure 6 As, Cd and Cr contents of banana varieties

Table 3 Mineral contents of selected banana varieties on fresh weight basis

Mineral elements	SK	AK	KK	RT	PU
	mg/100 g	mg/100 g	mg/100 g	mg/100 g	mg/100 g
Na	2.96±0.38 ^d	1.20±0.18 ^e	6.36±0.11 ^a	5.69±0.13 ^b	4.21±0.01 ^c
Mg	39.54±0.67 ^{bc}	40.80±1.04 ^b	37.96±0.54 ^c	43.09±0.36 ^a	35.63±0.42 ^c
K	490.50±4.82 ^b	524.91±14.59 ^a	554.41±7.50 ^a	569.75±15.77 ^a	487.39±0.68 ^b
Ca	58.72±3.17 ^a	52.24±1.12 ^b	45.48±1.60 ^c	41.09±3.07 ^c	61.62±0.10 ^a
Al	0.45±0.02 ^b	0.82±0.05 ^a	0.37±0.01 ^b	0.43±0.08 ^b	0.15±0.02 ^c
Mn	3.39±0.12 ^a	3.05±0.03 ^{bc}	2.95±0.01 ^c	3.10±0.00 ^{bc}	3.16±0.02 ^b
Fe	3.63±0.19 ^a	2.29±0.55 ^b	1.71±0.04 ^b	1.91±0.20 ^b	1.66±0.09 ^b
Cu	0.34±0.01 ^a	0.23±0.01 ^b	0.21±0.00 ^c	0.22±0.00 ^{bc}	0.23±0.00 ^b
Zn	2.09±0.03 ^a	2.10±0.00 ^a	1.92±0.01 ^b	0.48±0.10 ^c	0.49±0.00 ^c
Rb	2.29±0.09 ^b	2.69±0.14 ^a	1.12±0.00 ^d	1.61±0.04 ^c	2.42±0.00 ^b
Sr	0.35±0.00 ^a	0.33±0.00 ^a	0.24±0.01 ^b	0.20±0.01 ^c	0.22±0.01 ^{bc}
Ba	0.63±0.06 ^a	0.53±0.04 ^a	0.55±0.04 ^a	0.39±0.00 ^b	0.60±0.01 ^a
	μg/100 g	μg/100 g	μg/100 g	μg/100 g	μg/100 g
Cr	101.14±2.62 ^a	64.74±5.40 ^b	16.40±0.14 ^c	21.79±0.17 ^c	19.22±0.89 ^c
Co	3.97±0.01 ^a	2.78±0.13 ^b	2.05±0.07 ^c	1.56±0.36 ^d	1.69±0.04 ^{cd}
Ni	18.39±0.29 ^a	16.43±0.32 ^b	16.69±0.80 ^{ab}	17.42±1.23 ^{ab}	10.55±0.53 ^c
As	0.30±0.09 ^{bc}	0.88±0.05 ^{ab}	0.95±0.02 ^{ab}	0.19±0.04 ^c	1.25±0.00 ^a
Se	6.01±0.71 ^a	1.51±0.35 ^d	4.50±0.18 ^b	3.30±0.51 ^{bc}	2.76±0.92 ^{cd}
Li	4.78±0.09 ^b	5.69±2.53 ^a	4.79±0.20 ^b	4.24±0.96 ^b	4.95±0.16 ^b
Be	0.17±0.06 ^a	0.04±0.01 ^b	0.09±0.00 ^b	0.09±0.00 ^b	0.08±0.01 ^b
V	1.59±0.61 ^{ab}	1.97±0.50 ^{ab}	1.59±0.02 ^{ab}	2.35±0.61 ^a	0.94±0.01 ^b
Ga	5.32±0.25 ^a	4.20±0.14 ^{bc}	4.01±0.12 ^{bc}	4.47±0.61 ^b	3.56±0.03 ^c
Mo	5.79±0.43 ^a	1.08±0.07 ^c	1.09±0.06 ^c	0.91±0.11 ^c	2.83±0.42 ^b
Cd	0.66±0.03 ^a	0.43±0.06 ^{ab}	0.50±0.07 ^{ab}	0.46±0.09 ^{ab}	0.16±0.06 ^c
Bi	0.01±0.00 ^b	0.01±0.00 ^b	0.01±0.00 ^b	0.03±0.00 ^a	0.01±0.01 ^b

Data represent the mean values±SD (*n*=3) of three independent experiments. Means followed by the same letters in a row are not significantly different at a particular probability level by Duncan's multiple range test.

The values obtained for mineral elements in these banana varieties confirmed the findings of many authors such as Deraniyagala *et al.* (1994), Wall (2006) and Longvah *et al.* (2017). Though they were different varieties of *Musa* spp. from different countries, similar range of values had been resulted. RDA/ Adequate Intake (AI) of minerals can be compared with mineral contents of banana assuming complete absorption to the body. Banana was a reasonably good source of Cr, Fe, Mg, Mn, Zn, Cu and K which showed closer values to RDA /AI. RDA of Cr, Fe, Mg, Mn, Zn, Cu and K for a person aged 19 - 70 years could be solely met by intake of about 19 - 213 g, 220 - 1084 g, 0.7 - 1.2 kg, 53 - 78 g, 0.4 - 2.3 kg, 428 g, 825 - 964 g of studied banana varieties respectively. The inorganic arsenic lower limit on the benchmark dose for a 0.5% increased incidence of lung cancer (BMDL_{0.5}) was determined from epidemiological studies to be 3.0 μg/kg of body weight per day (JECFA, 2010). According to that, lower limit of As for a person who weighs 60 kg is 180 μg/d. Provisional tolerable monthly intake of Cd is 25 μg/kg body weight (JECFA, 2010). Based on that, provisional tolerable daily intake of Cd for a person who weighs 60 kg is 50 μg. When these recommended tolerable intakes are considered,

despite the fact that banana contained substantial amount of As and Cd, they were still far below the harmful levels.

Conclusion

This study was carried out to assess and to identify the significance of the proximate and mineral composition of selected five varieties of banana grown and consumed commonly in Sri Lanka namely, *Seeni kesel*, *Ambul kesel*, *Kolikuttu*, *Rathambala* and *Puwalu*. The results of the study indicate that banana is a good source of nutrients: carbohydrates and minerals (especially Cr, Fe, Mg, Mn, Zn, Cu and K). Comparatively, *Seeni kesel* contained higher ash and carbohydrate contents than other studied banana varieties while *Kolikuttu* and *Puwalu* were comprised of the highest protein and the highest fat contents respectively. Generally, *Seeni kesel* is superior in studied nutrients than other varieties in accordance with all the results of this study.

Among greatly concerned heavy metals, Cr and Cd contents were comparatively higher in *Seeni kesel* than other examined varieties and the highest As content was found in *Puwalu* which might be resulted by malpractices of cultivation, artificial ripening, packaging and storage. Moreover, these results suggest that consumption of sufficient amount of banana grown under safe farming practices and make available for consumption under safe ripening techniques could beneficially contribute to the nutritional requirement of human. Furthermore, study of the bioavailability of nutrients would be beneficial in food consumption surveys, diet recommendation and in mediating nutrient deficiency, nutrient adequacy and nutrient toxicity of populations.

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