Physicochemical Profiling of Released and Pipeline Desert and Cooking Banana Varieties in Ethiopia

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Abstract

Banana (Musa spp.) is an important ingredient of several dishes. However, the nutritional and biochemical compositions of released desert and cooking banana varieties in Ethiopia have not yet been studied. In the present study, a total of 13 released and pipeline cooking and desert banana genotypes were selected and their physicochemical quality profile was determined. A randomized complete block design with three replications was used. Length, width, peel and pulp thickness, pulp to peel ratio, total soluble solids, pH, titratable acidity, ash, and moisture content of fresh fruits and their mineral contents were determined. The difference between varieties was significant (P≤0.05) for fruit physical characteristics. Fruits of variety Cardaba were found to be the heaviest and the longest. While varieties Kitawira and Nijiru had the smallest, shortest, and thinnest fruits. Variety Cardaba, Nijiru, Matoke, and Kitawira had more pulp weight than peel weight. Most fruit chemical quality parameters were significantly (P≤0.05) affected by the varieties. The chemical composition of the flour also varied with variety and type of banana. Among others, variety Cardaba was found to have higher fruit weight, juice volume, total soluble solids, and dry matter, but lower total titratable acidity. Flour potassium content varied from 246.288 to 375.949 mg/100g depending on the variety. Similarly, 41.200 – 89.132 mg/100g phosphorus, 0.705 – 19.352 mg/100g sodium, 2.497 – 3.359% ash, and 71.529 – 76. 564% moisture contents were observed for different varieties. The sensory analysis of desert banana types was also evaluated, but there was no significant difference between varieties and most were in the acceptable range. The current study revealed variations in the biochemical composition of desert and cooking banana varieties, which could be used for different food product development by food processors in Ethiopia.

Keywords: Desert and Cooking banana, Mineral, Composition, Proximate analysis, and Sensory quality

Introduction

Banana is one of the most widely distributed and consumed fruit in the tropical and subtropical countries of the world (Robinson and Saúco, 2010). Banana is the common name of herbaceous plants of the genus *Musa* and for the fruit they produce. Banana plants are monocotyledons and perennial include desert, plantain, and cooking types. Plantain and cooking banana (*Musa* spp. AAB and ABB groups) is cultivated mainly as a carbohydrate staple in many developing countries, especially in Africa (Pereira and Maraschin, 2015). According to the Food and Agriculture Organization of the United Nations statistical division

(FAOSTAT, 2013), 106,714,205 tonnes and 37,877,805 tonnes of banana and plantains are produced worldwide, with about 16 % and 72 %, respectively produced in Africa. The production of both types, however, is affected by several factors (Stover 1987).

In Ethiopia, banana production is concentrated in the southern region of Ethiopia and the major production comes from small-scale growers. The average banana production in 1961 was 60,000 tons and grew to 270,000 tons in 2011. Its production and utilization have many technical, economic, and social problems that attract research attention to exploit its immense suitability potential (Tefera *etal*. 2014). The Ethiopian Institute of Agricultural Research (EIAR) has introduced some banana germplasm and collected both desert and cooking types. These materials have been evaluated by Werer, Melkassa, and Jimma Agricultural Research Centres and as a result, four cooking type banana varieties (Cardaba, Kitawira, Matoke, and Nijiru) were released in 2006 by Melkassa Agricultural Research Centre based on their better agronomic performance and disease resistance level.

New economic strategy to increase utilization of banana includes the production of banana flour when the fruit is unripe and incorporating the flour into various innovative products such as slowly digestible cookies (Saifullah *etal*., 2009), high-fiber bread (Adeniji, 2015) and edible films (Narayana and Pillay, 2011). The development of new products with banana is a strategic area in the food industry as it is one of the world's leading food crops with rich sources of minerals, vitamins, carbohydrates, flavonoids, and phenolic compounds (Wishart, 2008). It can be consumed as cooked as well as in uncooked forms (Sun- Waterhouse, 2011). In Ethiopia, the bulk of bananas produced in the country are utilized in the domestic markets as fresh fruit with a few processed products like chips. There is immense potential for processing banana into several value-added products like dehydrated ripe banana jam, jelly, fruit bar, wine, vinegar, puree, baby food, and pickle which can fetch profit both in the domestic as well as in the foreign market (Belayneh *et al*, 2014).

The production and utilization of different banana varieties have been consistently increasing in Ethiopia since 2006. Yet the physicochemical and mineral composition of the varieties are not well known as most research works conducted in the country focused mainly on the selection of promising varieties in terms of yield, cold tolerance, and disease, and insect pest resistance without giving much attention to post-harvest and processing quality attributes (Berhe et al. 2008). Therefore, the present work was undertaken to study the nutritional and mineral compositions of the different desert and cooking banana varieties and to evaluate their sensory characteristics for further use.

Materials and Methods

Materials

Four locally released cooking banana varieties, namely; Cardaba (ABB, Saba banana/2006-MARC/EIAR), Kitawira (AAB, 2006-MARC/EIAR), Matoke (AAB, 2006MARC/EIAR), and Nijiru (AAB, 2006-MARC/EIAR), and nine desert type and pipe-line genotypes were used for this experiment. The fruits were collected from Melkassa agricultural research center horticultural crops experimental field. Fruit bunches were examined about three months before harvest to make propping as per the requirement of the plant. Finally, matured fingers were harvested using visual banana maturity indices, by hanging bunches and observing individual fingers angularity. The harvested bunches were carefully transported to Melkassa agricultural research center's food science and nutrition research laboratory. Fresh bunches were used to conduct the whole experiment and fruits of cooking banana types were processed for further analysis.

Preparation of sample and experimental design

Harvesting of bunches was done three times depending on the availability of matured fruits and each variety had 15 bunches for analysis. The harvested bunches were stored at ambient conditions (28–31 °C and 56–62 % RH) on a wooden shelf. Twenty fruits were randomly selected from the proximal, midsection and distal hand positions of five bunch harvested each time and the fruits were washed and peeled. The peeled fruits were cut into slices of 0.5 cm thick disc using a vegetable slicer. The slices were then chopped, thoroughly mixed with a Hobart cutter. Dried samples were ground, sieved, and stored at room temperature (25˚C ± 2˚C) in airtight containers and the powdered sample was used for further analysis of chemical compositions. Furthermore, the composite samples from each variety were sub-divided into three sets and arranged in a randomized complete block design (RCBD) with three replications. Fruit peel, pulp weight, juice volume, total soluble solids, and total titratable acidity were determined using each sample set of fresh fruits. From each sample set ten sample fruits were randomly taken and used for the determination of fruit physical, chemical, and mineral compositions.

Physical quality analysis

Fifteen fruits from each set were used for the analysis of physical parameters. All fruit physical quality evaluations were done according to the procedure described by Dadzie and Orchard (1997). The finger girth and length of each fruit were measured by meter tape. The fruit volume was measured using the displacement method in a water-filled measuring cylinder. Fruit peel and pulp weights were measured using a beam balance. The average weight of each bunch was determined using sensitive balance (±0.1 g). Fruit length measurements were done on the outermost curvatures of the fruits taken from the proximal, midsection, and distal hand positions of the bunch samples. The same samples were used to measure fruit width at the widest midpoint of the fruit. Pulp and peel weights were determined after fingers were hand-peeled and both peel and pulp were weighed separately using an analytical balance. Then, the pulp to peel ratio was calculated after each sample fruit was transversely cut at the midpoint and hand peeled. Peel and pulp thicknesses were measured with a digital micro-caliper. In addition to pulp to peel ratio, pulp thickness was used as easy to peel indices. Initial pulp mass, firmness, dry matter content and moisture content of the fruits were measured (Belayneh *et al*., 2014).

Chemical composition analysis

Among the chemical properties, total soluble solids (TSS), dry matter (DM), pH and total titratable acidity (TA) were measured according to the procedure mentioned INIBAP technical guidelines (Tigist *et al.*, 2013). TSS was measured by blending 30 g of pulp tissue that was taken from the transverse section of the fruit in 90 m1 distilled water for 2 min in a blender and the slurry was filtered through filter paper Whatman No. 20 cm. A single drop of a filtrat was placed on a prism of calibrated digital handheld refractometer (Misco®, USA) with a degree Brix range of 0–32 % and resolutions of 0.2 °Brix at 20 °C. The pH value of the filtrate was determined using a pH meter (ELE International, U.K). Ten g of sample was weighed and it was macerated with 100 ml of deionized water. It was thoroughly mixed and the mixture was allowed to stand for 30 minutes. The supernatant was collected by centrifugation at 7863 RPM for 15 min using refrigerated centrifuge and was decanted and used for determination of pH. Titrable acidity(TA) of the filtrate was measured by titrating against sodium hydroxide to phenolphthalein endpoint and calculating the acid present as malic acid(Vermeir et al. 2009). The flour sample was analyzed for proximate composition according to the procedure of (Vermeir *et al*., 2009). Moisture content was determined by weighing 5g of the sample and drying in an oven at 105 ^{0}C to a constant weight. Ash content was determined by incineration of 5g of the sample in a muffle furnace at 525 ^{0}C and the weight of the ash was calculated by difference method (Jackson and Badrie, 2002).

Mineral analysis

The procedure of wet ashing was used to eliminate inorganic materials from the samples. About 0.5 g of the sample was weighed into a 250 ml beaker. Twenty-five ml of concentrated nitric acid was added and the beaker was covered with a watch glass. The sample was digested with great care on a hot plate in a fume chamber until the solution was pale yellow. It was then, cooled and 1 ml perchloric acid (70 % $HClO4$) was added. The digestion was continued until the solution was colourless or nearly so (evaluation of dense white fumes indicates the removal of nitric acid). When the digestion was completed, the solution was cooled slightly and 30 ml of distilled water was added. The mixture was brought to boil for about 10 min and filtered hot into a 100 ml volumetric flask using a Whatman No. 4 filter paper. The solution was then made to the mark with distilled water(Latef and Chaoxing 2011).

Two ml of the digest was used for the determination of sodium and Potassium using flame photometric (Jenway, United Kingdom) model PF P7 with methane gas (Lima, 1996) for phosphorus determination two ml aliquot of the digest was reacted with 5.0 ml molybdic acid, which was prepared by dissolving 25 ml of ammonium molybdate in 300 ml distilled water; with 75 ml of concentrated sulphuric acid in 125 ml of water to get 0.5 l of molybdic acid, and 1 ml each of 1 % hydroquinone and 20 % sodium sulfite was added in that sequence. Then, the solution was made up to 100 ml and allowed to stand for 30 min in order to allow the color to stabilize after which the absorption was measured at 680 nm. A standard curve colorimetric reading versus concentration of phosphorus was drawn using portions of standard phosphorus solutions (1, 2 and 3 ml) subjected to reactions with molybdic acid, hydroquinone, and sodium sulphate solutions. All readings were corrected by the reading of a blank to eliminate the effect of any color produced by the reagents. The phosphorus content was expressed as mg/100g of sample.

Sensory evaluation

A total of 21 male and female semi-trained panellists were used. Each panellist was first briefed with the important sensory evaluation conceptual knowledge and then, provided with a score sheet that was specifically designed for this experiment, a pen, pure water for mouth rinsing and fresh fruit samples. Each panellist received and evaluated the same amount of duplicate coded sample in a controlled sensory evaluation laboratory with separate boxes. The samples were evaluated on the basis of their texture, taste, color, peel conditions and overall acceptability and, all panellists scored the samples for each quality feature using a hedonic scoring scale of 1 to 5(Leksrisompong *et al.*, 2012).

Statistical analysis

One-way ANOVA was carried out to examine whether the difference between samples was significant for physicochemical properties, proximate composition, mineral content and sensory evaluation Comparison between the sample means was done using least significant differences (LSD) at 5 % probability level.

Results and Discussion

Physical and chemical characteristics

The physical and chemical characteristics of released and pipeline banana cultivars are summarized in Tables 1 and 2. Variety had highly significant ($p\leq$

0.001) effect on most of the fruit physical quality parameters of released and pipeline desert banana varieties (Table 1).

Table 1: Physical characteristics of released and pipeline desert banana varieties

Varieties	Length(mm)	Width(mm)	Peel Thickness(mm)	Pulp/peel Ratio
Chinese Dw	185.91[a]	45.157[a]	3.3220[b]	2.4633[c]
Ambowha Se	185.86[a]	39.067[c]	3.1273[b]	2.0913[d]
Dinke-1	173.98[a]	37.914[c]	2.1043[c]	2.9330[ab]
Paracido-E	159.54[b]	39.860[bc]	4.2033[a]	2.3827[cd]
Ambo-2	150.88[bc]	40.443[bc]	3.0287[b]	2.8390[b]
Williams-H	150.56[bc]	42.911[ab]	2.3067[c]	2.9960[ab]
Lady Finge	150.21[bc]	38.107[c]	4.1000[a]	2.2483[cd]
Dinke-2	150.09[bc]	38.379[c]	3.2000[b]	2.2117[cd]
Ambo-3	138.89[c]	38.163[c]	3.1760[b]	3.1873[a]
LSD	13.600	3.3498	0.5362	0.3324
F-Calcu	14.0	4.93	14.8	12.7
CV	4.93	4.88	9.85	7.47
P -value	0.0000	0.0024	0.0000	0.0000
Significance	***	***	***	***

*, ** and ***show significant at $P \leq 0.05$, $P \leq 0.01$ and 0.001, respectively; means followed by the same letter(s) within a column are not significantly different at $p \leq 0.05$

The result of physical quality parameters of released and pipeline desert banana varieties presented in Table 1 showed there was highly significant difference between varieties. Fruit length of variety Chinese Dw and Ambowha Se was found to be 185.91 mm and 185.86 mm, while that of Ambo-3 was lower (138.89 mm). The fruit width ranged from 37.914 to 45.157 for variety Dinke-1 and Chinese Dw, respectively. The peel thickness important for pulp to peel ration. The lower peel thickness value indicates the highest pulp peel ration considering the same fruit weight. The fruit peel thickness value showed highly significant difference between released and pipeline banana varieties. The value of peel thickness ranged from 2.1043(Dinke-1) to 4.1000(Ledy finge).

The result of the physico-chemical parameters of released and pipe-line banana verities presented in Table 2. Fruit PH value ranged from 4.69 to 5.20 for variety Ambowha Se and Dinke-2,respectively. Total soluble solid values showed highly significant difference between pipeline and released banana varieties. Variety Williams-h showed the highest while Ambo-3 showed the lowest values compared to other pipe-line varieties. Titrable acidity values also showed highly significant difference between released and pipeline banana varieties, where variety Ladyfinger showed the highest and Dinke-2 showed the lowest values.

Table 2: Physico-chemical parameters of released and pipe-line banana verities

Varieties	PH	TSS(brix)	TA(g/10ml)	TSS/TA	MO(%)	Ash%)
Dinke-2	5.2000[a]	23.700[abc]	3.7103[c]	6.3970[a]	72.582[e]	3.1210[ab]
Dinke-1	5.1977[a]	22.133[cd]	4.9220[b]	4.4983[cd]	73.355[d]	2.7710[c]
Ambo-2	5.1633[ab]	22.300[bcd]	3.7300[c]	5.9837[a]	75.543[b]	3.0450[b]
Ambo-3	5.0170[abc]	20.000[e]	4.8913[b]	4.0957[d]	76.564[a]	3.3587[a]
Chinese dw	4.8540[bcd]	21.333[de]	3.9803[c]	5.3817[b]	74.823[c]	2.8747[bc]
Williams-h	4.8140[cd]	24.467[a]	5.0003[b]	4.8947[c]	71.529[f]	2.8687[bc]
Paracido-e	4.7873[cd]	21.000[de]	5.1383[b]	4.0873[d]	71.745[f]	2.497[d]
Lady finge	4.7177[cd]	23.967[ab]	5.9407[a]	4.0360[d]	71.651[f]	2.6487[cd]
Ambowha se	4.6903[d]	20.333[e]	5.9473[a]	3.4233[e]	75.707[b]	3.3107[a]
LSD	0.3165	1.6959	0.3375	0.4826	0.6970	0.2601
F-calcu	3.83	8.06	56.2	37.2	70.4	11.0
CV	3.74	4.47	4.09	5.92	0.55	5.15
P -Value	0.0085	0.0001	0.0000	0.0000	0.0000	0.0000
Significance	**	***	***	***	***	***

*, ** and ***show significant at p≤0.05, p≤0.01 and 0.001, respectively; means followed by the same letter(s) within a column are not significantly different at p≤0.05

Fruit moisture content ranged from 71.529 % to 76.564 % for variety Williams-h and Ambo-3, respectively. In line with this, it has been reported that bananas generally contain 60% - 68.6% moisture as they ripen; which gradually increases from 68.6% - 78.1% (Kookal and Thimmaiah, 2018). An increase in the moisture content during ripening might be due to carbohydrate breakdown, softening the tissue texture and osmotic transfer from the peel to pulp (Tapre and Jain, 2012). Fruit ash content ranged from 2.497 % to 3.359 % for variety Paracido-e and Ambo-3, respectively. Mineral composition of fruits also varied from one variety to another. This could probably be due to genetic differences. In line with this (Kookal and Thimmaiah, 2018) have reported that ash content of banana fruits shows variations, which may be due to the differential absorption capacity of minerals at different stages of fruits of the different varieties.

Physical and proximate composition of cooking banana types

The physical quality characteristics of cooking banana varieties are presented in Table 3. Fruit weight ranges from 178 g for Cardaba to 69g for Nijeru. In general, variety had a significant (p≤0.001) effect on most of the fruit physical quality parameters, except for total soluble solids (Table 4). Of the four cooking banana varieties considered in this study, Cardaba showed the best performance for most physical quality parameters, as it had the highest mean fruit weight and volume. Variety Cardaba and Matoke had higher values for fruit weight and length, while Nijiru and Kitawira showed lower values than the reported average fruit weight and length for multi-location trials. The higher values recorded for Cardaba and Matoke could be due to suitable agro-ecological conditions for better performance of the two varieties compared to variety Kitawira and Nijiru. Although there was no significant difference between varieties, TSS content was slightly affected by the genetic factor, which was found to be 1.5 % and 1.7 % for Nijiru and Cardaba, respectively (Table 3).

Table 3: Physical quality characteristics of the four cooking banana varieties

Varties	FW(g)	PLW(g)	PPW(g)	FL(cm)	PPR	JV(ml)	TSS (%)
Cardaba	178a	54a	124a	16a	2.30a	194a	1.70a
Kitawira	73c	30c	43c	12b	1.43b	65c	1.60a
Matoka	119b	48b	71b	17a	1.48b	119b	1.60a
Nijeru	69c	24c	45c	13b	1.88b	74c	1.50a
Mean	109.75	39.00	70.75	14.50	1.77b	113.00	1.60
CV	6.11	4.77	4.56	3.28	4.42	5.93	2.90
Significance	***	**	***	**	**	***	ns

*, ** and ***show significant at $p \le 0.05$, $p \le 0.01$ and $p < 0.001$, respectively; means with the same letter within a column are not significantly different at $p \le 0.05$. FW: fruit weight; PLW: peel weight; PPW: pulp weight; FL: fruit length; JV: juice volume; PPR: pulp to peel ratio and TSS: total soluble solids.

Results of proximate composition are summarized in Table 4. Cooking banana varieties had no significant ($p>0.05$) effect on fruit pulp pH values. Nevertheless, the high pH level for variety Cardaba was similar with the value previously reported for banana fruit at a matured green stage (Dadzie, 1998). The TA value for Matoke was significantly higher ($p<0.05$) than that of variety Nijiru, Kitawira and Cardaba (Table 4). This indicates that Matoke contains higher amount of malic acid in its pulp. The results of the present study were in agreement with the findings of Ferris et al.(1999) who reported that malic acid contents ranges from 1.5 % to 2.5 % at harvest time for cooking banana, which could be used as an indicator of maturity of the crop (Dadzie and Orchard 1997). Variety Cardaba had the highest fruit physical properties and significantly ($p \le 0.05$) higher dry matter content as compared to the other varieties (Table 4).

The dry matter result content recorded in the present study from what has been reported by Ferris et al. (1999), which was 30.4 % for Cardaba. On the other hand, the values recorded for varity Matoke, Nijiru, and Kitawira agree with the findings of Agunbiade et al. (2006). Fruit moisture content ranged from 7.89% to 9.61%. An increase in the moisture content during ripening might be due to carbohydrate breakdown, softening the tissue texture and osmotic transfer from the peel to pulp (Agunbiade, 2006). The two cooking banana varieties, Kitawira and Nijeru had significantly higher moisture content, while Matoka had the lowest value. The moisture content of the samples seemed inversely related to dry matter content as it has and have been shown to be a useful quality-screening attribute. In line with this it has been reported that selection of new progenies based on dry matter content provides an efficient way of eliminating materials with low-quality fruit (Ferris et al. 1999). It has also been reported that dry matter decreases with maturation(Emaga *et al*. 2007). Probably due to carbohydrate utilization during maturation and osmotic transfer of water from the peel to the pulp.

Table 4. Proximate composition of cooking banana varieties

Varieties	PH	TA(g/100ml)	DM(%)	Ash(%)	Mo(%)	CP(%)	CF(%)	CFt(%)	Carb
Cardaba	6.1a	1.8b	29a	2.00a	8.11b	0.99b	2.71a	1.04a	85.15a
Kitawira	5.9a	2.1b	19b	1.69b	9.61a	0.93b	2.13ab	1.11a	84.53a
Matoka	5.9a	2.9a	22b	1.32c	7.89b	1.40a	2.67a	1.24a	85.48a
Nijeru	5.9a	2.0b	20b	1.60b	9.33a	0.91b	2.93a	1.07a	84.16a
Mean	5.95	2.20	22.50	1.65	8.74	1.06	2.61	1.12	84.83a
CV	1.97	4.51	6,72	4.21	3.77	1.89	2.00	2.14	1.11
Significance	ns	*	*	**	**	*	ns	ns	ns

*, ** and ***show significant at p≤0.05, P≤0.01 and 0.001, respectively; means followed by the same letter(s) within a column are not significantly different at p≤0.05. TA: titrable acidity; DM: dry matter; MO: moisture content; CP: crude protein; CF: crude fiber; CFt: crude fat and Carb: carbohydrate

Ash content of the samples also showed a significant difference for the released cooking banana varieties. This could be due to variations in the mineral composition of bananas during ripening, as the ash content increased with ripening (Adeyemi and Oladiji, 2009). In line with this (Kookal and Thimmaiah, 2018) have reported that ash content of banana fruits shows variations, which may be due to the differential absorption capacity of minerals at different stages of fruit development. Crude protein content of fruits also showed significant difference among the varieties (0.91 – 1.40%), which could probably be attributed to variations in genetic mark-up, altitude and climatic conditions(Kookal and Thimmaiah, 2018). Crude fat content of the cooking banana samples was generally low. Nevertheless, variety Matoka had higher (1.24%) and Cardaba had lower (1.04) values (Table 4). In line with this , it has been reported that bananas with low lipid and high energy contents are very useful for the manufacturing of low fat diet formulations(Giami and Alu, 1994). Crude fiber content of fruits of cooking banana varieties ranged between 2.13 and 2.93 g/100g. The highest crude fiber content was observed for variety Nijeru (2.93 g/100g). While, low fiber level of banana can be used for fortifying the weaning food. It has been reported that those fruits with high fiber content are desirable in adult diet, which is known to aid digestion, prevent constipation, help in the excretion of wastes and toxins from the body and prevent colon cancer(Gharibzahedi *et al.*, 2017).

Mineral composition

Banana is rich source of mineral nutrients and it could serve as a mineral element supplement in diet for both humans and animals (Soetan *et al*, 2010). Mineral nutrients such as potassium, phosphorus and sodium content of banana samples are given in Figures 1, 2, and 3. The observed values of potassium in banana samples ranged from 375.95 to 246.29 mg/100g. Phosphorus content of the samples was between 89.13 to 41.20 mg/100g, while that of sodium was within the range of 19.35 to 0.71 mg/100g. Potassium, phosphorus and sodium contents of banana sample varied from one variety to another, probably because of differences in genetic make-up of the varieties(Gibson *et al.*, 2010).

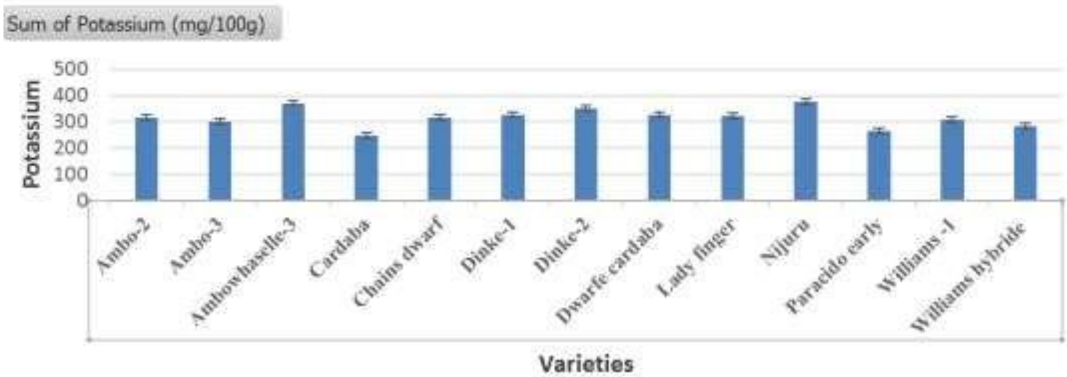

Figure 1: Fruit potassium content (mg/100g) of banana varieties

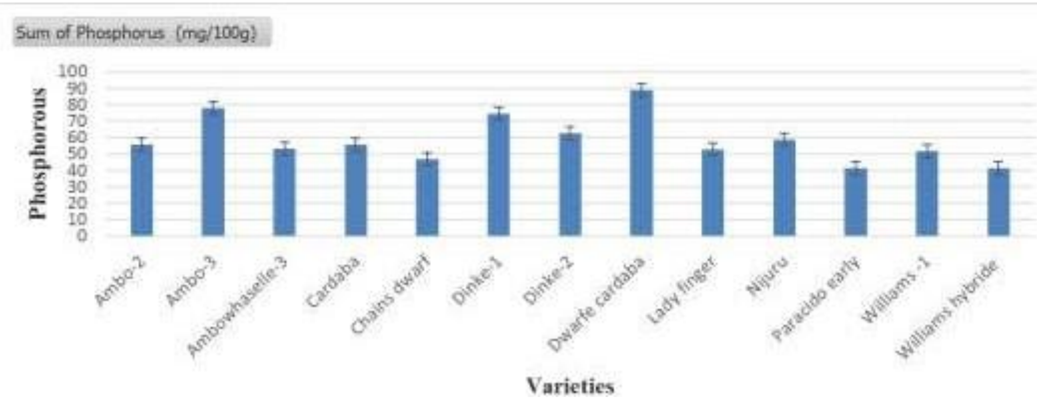

Figure 2: Fruit phosphorus content (mg/100g) of banana varieties

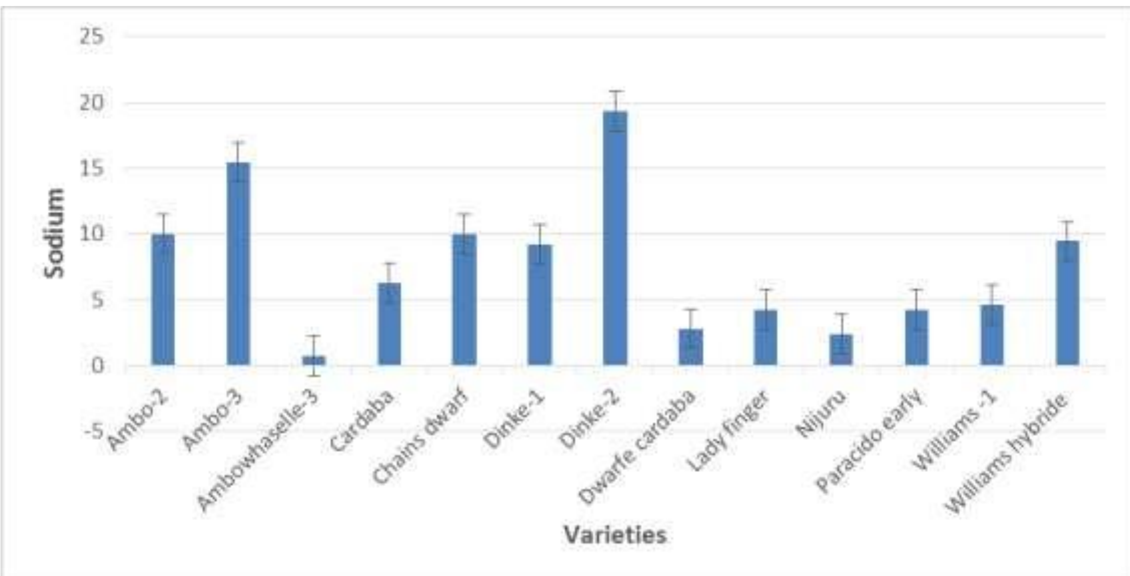

Figure 3: Fruit sodium content (mg/100g) of banana varieties

Sensory quality evaluation

For comprehensive new variety evaluation, assessing the utilization aspects is very crucial. Accordingly, color of the fresh banana fruit is one of the important attributes in the assessment of consumer preference. In the present study, panellists indicated that there was no significant difference among the fresh fruit samples for color (Table 5).

Table 5: Sensory quality of fresh fruit from desert type banana varieties

Varieties	Color	Peeling conditions	Texture	Taste	Oder	Overall acceptability
Ambo-2	4.167[a]	4.006[ab]	4.199[a]	3.917[abc]	4.2117[a]	4.2500[ab]
Dinka-2	4.097[a]	4.285[a]	4.063[a]	3.667[bcd]	3.8753[a]	4.0140[abc]
Lady finge	4.069[a]	4.208[a]	4.110[a]	4.214[a]	4.2380[a]	4.3840[a]
Dinke -1	3.774[a]	3.673[ab]	3.713[ab]	3.552[bcd]	3.8317[a]	3.8033[bc]
Paracido aerly	3.767[a]	3.513[b]	3.942[ab]	4.042[ab]	3.8253[a]	3.9573[abc]
Williams h	3.746[a]	3.696[ab]	3.750[ab]	3.492[cd]	4.0877[a]	3.9293[abc]
Chinese dw	3.722[a]	3.366[b]	3.2897[b]	3.345[d]	3.6353[a]	3.5657[c]
Ambowhasel	3.709[a]	3.783[ab]	3.750[ab]	3.894[abc]	3.6510[a]	3.8387[abc]
Ambo-3	3.708[a]	3.750[ab]	3.750[ab]	3.833[abcd]	3.5833[a]	3.7083[bc]
LSD	0.5956	0.6547	0.7282	0.5352	0.8079	0.5565
CV	8.99	10.02	10.99	8.27	12.13	8.24
Significance	ns	Ns	ns	Ns	ns	ns
F-calcu	0.90	1.92	1.26	2.42	0.82	1.86

Each observation is a mean (no of panellists=21). Ns= non-significant. Means followed by same letter(s) within a column are not significantly different at $p \leq 0.05$

This result clearly indicated that screening of new varieties only with physicochemical properties could not be complete without sensory evaluation. In the present study, there were no significant differences ($p>0.05$) among the desert banana varieties for fruit fresh texture (Table 5), through the values indicated that the fruits had very hard to good texture. In line with this, it has been reported that specific gravity has a direct relationship to the processing efficiency, texture, and yield of different products (Belayneh *et al.,* 2014). Hence, like the case with fresh fruit texture non-significant difference was observed for specific gravity and firmness of the fruits. The sensory evaluation also did not detect significant differences ($p>0.05$) among varieties for fresh fruit taste (Table 5). In line with this, it has been reported that taste is mainly a balance between sugar and acid contents (Hailu *et al*., 2012).Thus, lack of significant difference in fresh fruit tastes could be linked to the similarity in TSS and pH of the fruits. According to the hedonic scoring scale, panellists indicated that fresh fruit from the different desert type banana varieties had well to very good overall acceptability. This indicates that consumers may not reject desert fresh banana fruits.

Conclusions

The results indicated that cooking banana types showed highly significant differences for most quality parameters and variety Cardaba had superior values for physical characteristics. On the other hand, variety Nijiru and Kitawira had the smallest, shortest and thinnest fruits with the edible portion mass almost equal to peel mass. Variety Cardaba had a higher proportion of pulp per unit mass. The chemical quality of thirteen matured fruit samples was found to be significant different for variety. The physicochemical quality of desert and pipeline banana varieties highly significantly varied. The good cooking qualities of Cardaba could be related to its ease of peel, lower water absorption potential, slightly higher pulp firmness before cooking, higher percentage of pulp dry matter content and greater pulp to peel ratio. On the other hand, variety Nijiru, Kitawira, and Matoke were relatively watery and produced a softer pulp up on cooking, indicating their lower suitability for cooking purposes. Sensory analysis of desert banana fresh fruit pulp showed that was no significant difference between varieties. It was observed that desert type of bananas are acceptable for fresh consumption and variety Nijiru, Kitawira and Matoke possess better potential for producing a more acceptable quality of processed products than does variety Cardaba. Hence, the results of this research will help the food industry to optimize nutritional compositions while designing new products that utilize those banana varieties as raw materials.

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