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Original Article

Nutritional Composition of White and Reddish-Orange Guava (*Psidium guajava*) L. Varieties Growing in Homa Bay County, Kenya

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ABSTRACT

Guavas in Kenya are mainly consumed at the household level. However, limited research and development are aimed at domesticating and commercializing the fruit. This has hindered the country's establishment and improvement of structured guava value chains. A nutritional assessment of guava varieties (white and reddish-orange) growing wild in Homa Bay County was done to explore their utilization potential. Stratified simple random sampling and standard nutrient assessment procedures were adopted. The samples were analyzed for moisture content, proximate composition, minerals, vitamin content, and calorific value based on standard procedures. The moisture content of the white variety was significantly higher than the reddish-orange variety at 84.60%±0.55 and 80.32%±1.61 respectively. However, the crude fibre in the reddish-orange variety was significantly higher than the white variety at 6.02%±0.11 and 3.49%±0.42 respectively. There was no significant difference in the ash content for the reddish-orange variety at 3.50%±0.15 and the white variety at 3.88%±0.29, as well as in protein (p=0.06) at 1.37%±0.19 and 1.84%±0.26, respectively, and fat content at 0.89%±0.07 and 1.16%±0.20, respectively. There was no significant difference in Vitamin C content in the white variety at 16.03±0.92mg/100g and reddish-orange at 9.3±0.00mg/100g, as well as in Niacin content in the reddish-orange variety at 3.63±0.03mg/100g and the white variety at 0.54±0.01mg/100g. The reddish-orange variety had significantly higher iron, potassium, and aluminium contents than the white variety, whereas there was no significant difference in their Sodium, lead, zinc, copper, and calcium contents. There was no significant difference in mean calorific values of the reddish-orange variety at 17.22±0.08 KJ/gram and the white variety at 16.88±0.31 KJ/gram. Considering the findings, the guavas can provide additional nutrients to households as well as the opportunity for exploitation in product development for income generation, thereby providing a means of preservation when the fruits are in season.

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INTRODUCTION

Guava, *Psidium guajava* L., is a small monoecious evergreen tree with a height of between 3-10 m belonging to the Myrtaceae family (Chiveu *et al*., 2017; Omayio *et al*., 2019). The species has a shallow root system. The plant produces low-drooping branches from the base and suckers from the roots (Heuzé *et al*., 2015). It originated from Southern America but is currently naturalized in Kenya (McMullin *et al*., 2016), where it grows well in different climate zones ranging from semi-arid lowlands to humid midlands (Kidaha *et al*., 2015). In parts of the Nyanza, Western, and Coast regions, where guava grows, they tend to become weeds as the seeds are distributed by birds (Kidaha *et al*., 2015). Various varieties of red/pink fleshed, white fleshed, and strawberry guava with diverse morphological and genetic diversities grow in Kenya due to the different agro-ecological zones (Gatambia *et al*., 2010; Kidaha *et al.*, 2015; Chiveu *et al*., 2019). A review by the Horticultural Crops Directorate on the status of fruits indicated that, in Kenya, the area under guava was 1,260 ha, which produced 11,327 tons valued at 111.6 million in 2014 (HCD, 2014). Guava is considered an invasive tree species in most regions in western Kenya, due to its allelopathic effects on native species (Kawawa *et al.*, 2016). It is invasive in most areas, and various mitigations have been proposed, such as the use of goats to feed on guava bark (Adrian *et al*., 2012; CABI, 2013).

The fruit has a high market potential, particularly appreciated both as a fresh fruit and an industrially processed product in the form of juices, jellies, and sweets. Processing of guava also yields 25% by-products that can be used in animal feeding (Azevêdo *et al*., 2011). Wood from the guava tree is useful for tool manufacturing, fencing, and fuelwood due to its good properties (Orwa *et al*., 2009). The leaves can be used as fodder, while the flowers are fragrant and a good source of nectar for bees (Orwa *et al*., 2009). In Kenya, the fruits are mainly consumed at the household level. A study by (Wasilwa *et al*., 2018) that preference for guava changes between genders and is based on availability and type.

The challenges and gaps in the utilization of guavas in Kenya include: limited processing and value addition due to limited knowledge and lack of processing equipment (Omayio *et al*., 2020), high post-harvest losses, poor market access and low prices and seasonal overproduction and concentrated harvest (Omayio *et al*., 2022). There is also limited research and development aimed at their domestication and commercialization, which have hindered the establishment and improvement of structured guava value chains in the country (Omayio *et al.*, 2019).

Fruits from guavas are rich in antioxidants, vitamin C, potassium, and fibre. Studies by (Omayio *et al*., 2022) show that the guava varieties (red/pink fleshed, white fleshed, and strawberry) have considerable amounts of vitamin

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C, potassium, and calcium. Guava has immense health benefits because of its variety of antioxidant content, which can fight inflammation and improve heart health, and digestion (Momaya, 2022).

In Homa Bay County, guava grows in abundance and holds significant potential as a low-cost source of essential nutrients. However, the fruit remains significantly underutilized in both household diets and commercial value chains. One of the critical barriers to its utilization is the lack of comprehensive, variety-specific nutritional data on guava growing in the region. Both white and reddish-orange guava varieties grow widely in the County yet no published studies have systematically compared their nutritional composition. This gap limits informed decision-making among farmers, food processors, health professionals, and policymakers regarding the fruit's dietary applications, market positioning, and potential for value-added processing. A detailed nutritional assessment is therefore essential to support guava's inclusion in household diets and promote its commercialization thereby enhancing its role in addressing nutritional challenges in the County and similar agro-ecological zones. This study was therefore aimed at assessing and comparing the nutritional content of varieties (white and reddish-orange) of guava and exploring their potential for utilization within the Lake Victoria Basin.

MATERIALS AND METHODS

Study Site

The study was conducted in areas where the guava trees were growing wildly in Homa Bay County. The specific areas were Lambwe West Location in Suba North Sub-County, N.E. Kanyamwa, and South Kanyamwa in Ndhiwa Sub-County. Lambwe West Location is characterized by soils which are largely "black cotton" clays, and the climate is hot and humid, with an average annual air temperature of 25°C. The area is under the lower midlands (LM5) ecological zone (Ministry of Agriculture, Livestock and Fisheries, Kenya, 2016). Rainfall is bimodal, peaking in April–June and September–November. The dry and hot periods lie between January and March. Ndhiwa Sub-County has black cotton soils in nature with high levels of nitosols and osols. Other areas are dominated by alluvial soils, mainly the sandy loam type, which is well-drained. The area experiences two rainy seasons, the long and the short rains, which fall between February and March and between August and November, respectively. However, there are some dry seasons, such as in December and January (Ochieng *et al*., 2017). These selected sites have a high population and distribution of the white and reddish–orange guava varieties.

Sampling Design

The guava samples were collected randomly within the three locations where the wild guava fruits were picked from fruiting trees in Mirogi, Kamato, and Abuor areas. The total number of trees sampled per area was 50. Within each area, 5 guava tree stems were randomly selected and 10 healthy, undamaged, and clean fruits were picked from the selected trees for nutrient assessment (Table 1).

Table 1: Sampled Fruits

Sub County	Sub-Location	Areas	Type of fruit	No of trees	Sampled trees	Number of fruits picked
Ndhiwa	S. Kanyamwa	Mirogi	White	50	5	10
Mbita	Lambwe West	Kamato	Reddish-orange	50	5	10
Ndhiwa	N.E. Kanyamwa	Abuor	Reddish-orange	50	5	10
Total				150	15	30

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Determination of Proximate Composition

Moisture Content

The moisture content was determined by drying 5g of sample in an oven at 105ºC to constant weight, according to the Association of Official Analytical Chemists (AOAC) Method 930.04 (AOAC, 1995). The moisture level was computed as a ratio of the weight lost to the sample weight before drying, expressed as a percentage.

Crude Fibre Content

The crude fibre content was determined using the Henneberg-Strohmann method described by (Madhu *et al*., 2017), where 2g of sample was weighed into a 250 ml beaker and 200 ml of hot 1.25% sulphuric acid was added. The mixture was boiled for 30 minutes and then filtered through glass wool. The residue was washed with hot water and then returned to the beaker together with glass wool. Then 200 ml of 1.25% sodium hydroxide was added and boiled for 30 minutes. The resulting residue was then filtered and washed with 1% hydrochloric acid, hot water, ethanol, petroleum ether, and diethyl ether, respectively. The residue was transferred into clean crucibles and dried in the oven at 105°C for 1 hour. It was then cooled in a desiccator and weighed. The dried residue was incinerated at 550°C in a muffle furnace for one hour, cooled, and weighed. The crude fibre was calculated as a ratio of the lost weight during incineration to the initial sample weight, expressed as a percentage.

Crude Fat Content

The crude fat was determined by the Soxhlet's extraction method 920.85 (AOAC, 1995). The fat was extracted from 5 g of dry sample using hexane and determined gravimetrically after removing the solvent and drying in an oven. The amount of fat extracted was calculated as a ratio of the weight of fat extracted to the weight of the sample, expressed as a percentage.

Crude Protein

Crude protein was determined using the Semi-micro Kjedahl method, AOAC method 978.04 (AOAC, 1995) where 0.5 g of the fruit sample was digested with 15 ml of concentrated sulphuric acid and 0.2g of a catalyst mixture of sodium sulphate, copper sulphate, and Selenium (20: 2: 1). The digest was allowed to cool for 15 minutes, and 70 ml of deionised water was added. The solution was made alkaline with 50 ml of 10M (40% w/v) sodium hydroxide in a kjeltec distillation apparatus, followed by steaming for six minutes. The gaseous ammonia liberated was bubbled through 50 ml of 2% boric acid solution with bromophenol blue as an indicator, and the solution obtained was titrated against 0.025M sulphuric acid. The percentage of nitrogen was calculated by multiplying the mean volume of acid used in titration by a constant (14) and dividing by the weight of the sample multiplied by a constant (20). To get the protein content of guava samples, values obtained for nitrogen content were multiplied by a conversion factor (for plant tissues) of 6.25.

Ash Content

Ash content was determined by the (AOAC, 1995) method 930.05, where 5 g of the sample was charred and incinerated at 550°C until the ash turned greyish. The weight of the ash was determined gravimetrically and expressed as a percent of the sample weight taken.

Carbohydrate Content

The percentage carbohydrate content was determined by subtracting the sum of moisture, fat, ash, fibre, and protein from 100 (AOAC, 2006).

Analysis of Vitamins

Riboflavin, Niacin and Thiamine

The chromatographic analysis of vitamins was carried out using Shimadzu Prominence High Performance Liquid Chromatography (HPLC) CTO-20A in its isocratic mode. It consisted of an autosampler (model SIL-20A), a pump (model LC-20AD), an oven column (model CTO-20A) Shimpack C-18, 150mm by 4.6mm; 5 micron, a Fluorescence (model RF-20A), and UV/V is detector (SPD-20A). 20 ml of deionised water was added to 3gm of samples and agitated for 15

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minutes in an ultrabath to extract riboflavin. The resulting solution was filtered through a nylon microfilter membrane (0.45µM) and diluted twice with deionised water. The column temperature was set at 30^0C. The mobile phase was 70% acetonitrile and was buffered with 25 nM potassium dihydrogen phosphate and a flow rate of 1 mL/min. During the analysis of riboflavin, fluorescence detector excitation and emission wavelengths were set to 370nm and 450nm, respectively. The total chromatographic runtime was 15 min for every sample analysis. Conditions set for nicotinic acid were similar to those of riboflavin, apart from the UV/V detector wavelength that was set at 254nm. It took ten minutes to a total of 10 minutes to run each sample.

Levels of thiamine in fruit samples were determined as per the method described by (Oriwo *et al.,* 2022) where thiamine was converted to a fluorescent thiochrome by dissolving 0.1g of $K_3Fe(CN)_6$ in a 100 ml volumetric flask using deionised water to make a 1000 ppm solution. 5 ml of 5M NaOH and 0.2 ml of 1% potassium ferricyanide were put into a 100 ml volumetric flask. Then 10 ml of thiamine standard thiamine was added and topped to the mark using mobile phase to make a 100 ppm solution. Working standards were prepared by diluting the stock solution with the mobile phase. The excitation wavelength for the fluorescence detector was set at 385nm and 433nm for the emission spectrum. The run time for every sample was 10 minutes.

Vitamin C

Vitamin C was determined by the titrimetric method (AOAC Method 967.21). The sample was prepared by putting macerated samples into 50 ml of distilled water to which 25 ml of 20% metaphosphoric acid was added as the stabilizing agent, and this was then made to 100 ml with distilled water in a volumetric flask. Then 10 ml of this solution was titrated with a standardized 2, 6-dichlorophenolindophenol solution until a faint color appeared for 15 seconds. The ascorbic acid (vitamin C) was calculated as mg per 100 grams from the resulting titre values.

Determination of Mineral Content

Levels of minerals present in the samples were determined by digesting 2.0g of the raw sample with 10mls of HNO_3 (nitric acid). The resulting digest was filtered into a 50ml volumetric flask using acid-resistant filter paper, Whatman No. 542. The filtrate was topped up to the mark with distilled water. Specific elements were determined by running the samples in an atomic absorption spectrophotometer (AAS), Agilent AA55 Spectra. A range of concentrations of standards for each element was prepared from a stock solution and run to generate a calibration curve against which the unknowns were determined by aspirating them. The readings obtained were recorded as machine readings for each sample analyzed based on (AOAC, 2006) method 985.01. The mineral content expressed as mg/100g of sample was calculated as a ratio of the product of ASS reading and dilution factor and sample weight.

Determination of Calorific Value

Bomb calorimeter model Yoshida 1013J was used to determine the energy value of the samples weighing 1 g of each. The method used is as described by (Kobayashi *et al*., 2008).

Data Analysis

An Excel spreadsheet and Statistical Package for the Social Sciences (SPSS) version 22 were used to analyze the data. An independent sample t-test was used to determine the significant difference in the means ($p<0.005$) of the two guava varieties.

RESULTS AND DISCUSSIONS

Proximate Composition

Table 3 shows the results of the proximate analysis for both reddish-orange and white guava varieties. The white variety had a higher moisture content (84.60%) than the reddish-orange variety (80.32%). The difference in moisture levels between the two varieties could be due to physical attributes such as the presence of more solid

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matter in red guava, such as fibre. This could also be attributed to the presence of more porous spaces in white guava that can be filled with water. The moisture content for the red variety is, however, consistent with values documented by (USDA, 2018) at 80.8%. The ash content was lower for the reddish-orange variety at 3.50% wet weight basis (wwb), with the white variety having 3.88% (wwb). Results of both moisture and ash levels were lower compared to the values of 86.89% and 5.4% for moisture and ash, respectively, reported by Waziri & Saleh (2015) from Nigeria. The mean crude protein content of the guavas was at 1.37% and 1.84% (wwb) for the reddish-orange and white varieties, respectively, which were lower than the values reported by USDA at 2.55% (wwb). The crude fat content was higher at 1.16%, with the reddish-orange variety recording a lower value at 0.89% values of which is lower than the USDA data at 0.95%.

Table 2: Proximate Composition of Guava Varieties {% wet weight basis- (wwb)}

Parameter	Guava variety/ Proximate composition Reddish-Orange	White	t (df=4)	p-value	CI (95%) Lower	Upper
Moisture content	80.32±1.61	84.60±0.55	-4.355	0.01	-7.00868	-1.55132
Ash content	3.50±0.15	3.88±0.29	-2.107	0.10	-0.88855	0.12188
Crude Protein	1.37±0.19	1.84±0.26	-2.567	0.06	-0.98537	0.03870
Fat content	0.89±0.07	1.16±0.20	-2.236	0.09	-0.61275	0.06608
Crude fibre	6.02±0.11	3.49±0.42	10.19	0.01	1.83826	3.21508
Carbohydrate	7.91±1.38	5.03±1.10	2.828	0.05	0.05212	5.71455

The values are expressed as mean ± standard error; n=3 CI- confidence interval.

The total fibre in the red variety (6.02%) was higher than in the white variety at 3.49%. This agreed with the study by (Ioniță-Mîndrican *et al*., 2022) where it was reported that high moisture levels in fruits provide relatively low fibre content. The value for the reddish-orange variety is, however, higher than the values reported at 5.4%, while the white variety values are lower (USDA, 2018). Dietary fibre is important because of its health benefits including providing satiety which may reduce appetite, lowering variance in blood sugar levels, lowering total and LDL cholesterol, which may reduce the risk of cardiovascular disease, speeding up the passage of foods through the digestive system, which facilitates regular defecation and addition of bulk to the stool, which alleviates constipation. According to (USDA, 2019), 1g of guava can provide about 12% (3g) of the recommended dietary fibre. The results indicate that there is a statistically significant difference between the moisture content (p=0.01), Crude fibre (p=0.01), and carbohydrate (p=0.05). While the Ash content (p=0.10), protein (p=0.06), and fat content (p=0.09) were statistically insignificant. Hence, the two varieties of wild guava have differences in some of their proximate composition contents.

Vitamin C Composition

Vitamin C content in the white variety was higher at 16.03mg/100g and the reddish-orange variety was lower at 9.3mg/100g (Table 3). These values are however very low compared to the USDA values of 228.3mg/100g as well as studies by (Omayio *et al*., 2022) which showed that the red/pink fleshed and white fleshed had vitamin C levels of 1365.15mg/100g (217.33mg/100g wwb) and 1665.56mg/100g (286.97mg/100g wwb) of dry weight respectively. The levels are also low compared to 180mg/100g reported by Dauda & Sadisu (2013). The variations could be attributed to the condition and state of the samples at the time of the analysis since they were transported over a long distance to the laboratory, and the analysis was only done the following day. The levels of riboflavin for the reddish-orange variety (0.03mg/100g) were comparable to the USDA values of 0.04mg/100g.

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Table 3: Vitamin Content (mean) mg/100g (based on wet weight)

	Guava variety/Vitamin composition (mg/100g				CI (95%)	
Vitamin	Reddish-Orange	White	t (df=4)	p-value	Lower	Upper
Vitamin C	9.3±0.00	16.03±0.92	-12.681	0.01	-8.20	-5.25
Riboflavin	0.03±0.01	BDL				
Niacin	3.63±0.03	0.54±0.01	189.223	0.01	3.04	3.14
Thiamine	BDL	BDL				

The values are expressed as mean ± standard error; n=3; BDL: Below Detectable Level; CI – Confidence interval

The results indicate that there is a statistically significant difference between the vitamin composition with vitamin C content (p=0.00) and Niacin (p=0.00). Hence, the two varieties of wild guava have differences in their Vitamin C and Niacin contents. The significant difference in riboflavin content could not be computed because the content in the white variety was below the detection level of the machine.

Mineral Composition

Table 4 below shows the results of the mineral composition of the two varieties. The USDA report of 2018 shows that guavas have considerable amounts of calcium, magnesium, potassium, and iron. The test results show higher values of calcium (131.33mg/100g) for the reddish-orange variety and iron in both the white (0.93mg/100g) and reddish-orange (1.86mg/100g) varieties. The magnesium levels in the reddish-orange and white varieties were 31.47mg/100g and 34.33mg/100g, respectively.

Table 4: Mineral Content (mean) of Guava Varieties (mg/100g wet weight basis)

Parameter	Guava variety/mineral concentration (mg/100g, wwb)				CI (95%)	
	Reddish-orange	White	t (df=4)	p-value	Lower	Upper
Sodium	2.94±0.35	2.73±0.28	0.80	0.47	-0.51	0.93
Iron	1.86±0.43	0.93±0.26	3.25	0.03	0.14	1.74
Lead	1.45±0.37	1.05±0.11	1.78	0.15	-0.23	1.03
Zinc	0.55±0.04	0.53±0.07	0.46	0.67	-0.11	0.15
Copper	0.27±0.08	0.18±0.01	2.01	0.12	-0.04	0.23
Magnesium	31.47±0.72	34.33±0.41	-5.95	0.01	-4.18	-1.52
Potassium	411.45±0.53	397.22±0.31	40.36	0.01	13.25	15.21
Aluminium	0.14±0.02	0.07±0.01	5.66	0.01	0.04	0.11
Calcium	131.33±6.62	120.67±4.01	2.38	0.07	-1.75	23.06

The values are expressed as mean ± standard error; n=3; CI-Confidence interval.

Potassium in both the reddish-orange and white varieties, at 411.45mg/100g and 397.22mg/100g, respectively, is comparable to the USDA report (417mg/100g). However, the magnesium levels of 31.47mg/100g and 34.33mg/100g for reddish-orange and white varieties, respectively, were higher compared to 22mg/100g from the USDA report. There was a significant difference in the mean iron (p=0.032), magnesium (p=0.004), potassium (p=0.000) and aluminium (p=0.005) contents, with no significant difference in Sodium (p=0.468), lead (p=0.150), zinc (p=0.667), copper (p=0.116) and calcium (p=0.076) contents.

Calorific Value

Calorific value is the energy accumulated in food substances. All fruits are mostly made of carbohydrates, although calories in fruit can also come from fats and small amounts of protein. Table 5 below shows the test results for the calorific value of the two guava varieties. The calorific values of the two varieties (411.57

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Kcal/100g and 401.29 Kcal/100g) were very high as compared with values reported at 269.12 Kcal/100g (red fleshed) and 265.71 Kcal/100g (white fleshed) by (Omayio *et al*., 2022). The difference in the results with those of Omayio et al could be attributed to the method used, which was based on Atwater factors of 4, 4, and 9 for protein, carbohydrates, and fats, respectively, as opposed to the Bomb calorimeter model Yoshida 1013J used to generate the results of this study.

Table 5: Calorific Value {KJ/gram dry weight basis (dwb)}

Parameter	Guava variety/ Calorific values		t (df=4)	p-value	CI (95%)	
	Reddish-orange	White			Lower	Upper
Calorific value	17.22±0.08 (411.57 Kcal/100g)	16.88±0.31 (401.29 Kcal/100g)	1.83	0.14	0.17	0.85

The values are expressed as mean ± standard error; n=3; CI-Confidence interval.

The test results for the two varieties show that there is no significant difference in their mean calorific values at a 95% significance level, assuming equal variances, with the *P* value of 0.142 being greater than the significance level $\alpha = 0.05$.

CONCLUSION AND RECOMMENDATIONS

The results from the nutritional assessment indicate that there are appreciable amounts of minerals and dietary fibre in guavas; as such, they can be utilized as a direct source of nutrients. However, there were some variations in proximate composition, minerals, and vitamin levels compared to other studies. Other than the reasons already mentioned, the variations could also be due to the variation in agronomic treatments, management, soil composition, and climatic conditions. (Chiveu *et al*., 2019) Their findings show that there was a positive correlation between ascorbic acid content and annual precipitation, while there is a negative correlation with mean annual temperature. The protein content, however, had a positive and negative correlation with mean annual temperature and mean annual precipitation, respectively. A similar trend was observed for the mineral content of the guava samples. Further research should, however, be done to ascertain the effect of management practices and soil composition in the two varieties.

Despite the variations, both the white and reddish-orange varieties contain considerable nutrients that can offer potential health benefits. Including them in the diet can help boost nutrient intake and improve overall health. Even though guava value addition is still low in Kenya, communities can be trained on methods of value addition to enable them to get some income from the sales of processed products, which in turn will contribute to household food security.

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Declaration of Interest Statement

The authors declare no conflict of interest.

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