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PHYSICOCHEMICAL PROPERTIES OF THE KEITH AND JULIE VARIETIES OF MANGO (*MANGIFERA INDICA* L) IN YOLA, NIGERIA

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Abstract
Mango (Mangifera indica L), a climacteric tropical and sub-tropical fruit, has numerous health-related benefits. The physicochemical characteristics and proximate composition of mango fruits are useful for classifying mango varieties and understanding the benefits that could be derived from the fruits. There is a lack of information on the characteristics of Keith and Julie mango varieties in Nigeria. This study was carried out at the Department of Crop Production and Horticulture of Modibbo Adama University, Yola, to determine the physicochemical properties of fresh Keith and Julie mango fruits. The mango fruit were harvested on the orchard of the University at the matured green stage when they had clear, well-developed shoulders at the stem end. Data on the fruits were collected, including firmness, size, and weight pH, total soluble solids, trivial acidity, moisture content, carbohydrate, protein, fat, ash, crude fiber, dry matter, energy value, and vitamins. The results of the physicochemical properties showed that significant differences (P≤0.05) existed among the varieties with the Keith variety having higher levels of in some characters like total soluble solids (19.45°Brix) than Julie variety which had 13.90° Brix. Similarly, Julie had higher values in some characters like moisture content (83.67- 83.85%), Protein content (0.70 - 0.71), and vitamin C (52.87- 55.00 mg/100 g) when compared to Keith, who had moisture content of 79.30-84.00%, protein content of 0.13-0.28%, and vitamin C of 47.33 – 49.61 mg/100 g. These differences affect the taste, storability, and nutritional values derivable from the consumption of these fruits. may be the result of varietal differences, which could be consistent and diverse. These results may be useful to researchers interested in mango varietal improvement. It also provides information on maturity and taste indices, which are useful for those involved in the processing industry.

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1. INTRODUCTION

Mango (*Mangifera indica*, L.), a climacteric tropical and sub-tropical fruiting tree belonging to the genus *Mangifera indica*, is an evergreen tree belonging to the Anacardiaceae family that originated in the Indo-Burmese region. Mango is named the "King of fruits" due to its high palatability, sweetness, richness of taste, and flavor, variability, large production volume, and exemplary nutritive value (Farina *et al*. 2020). It has an oval, round, heart-shaped, kidney-shaped, or long and slender. The smallest mangoes are no longer than plums, while others may weigh between 1.8 and 2.3 kg. Some varieties are vividly colored with shades of red and yellow, while others are dull green (Britannica, 2024). Mango is consumed at all stages of its development. From the raw green stage to the ripe yellow stage, mangoes are enjoyed for their sweet and tangy flavor. They can be eaten fresh, added to smoothies, salads, and salsas, or even pickedled for a unique culinary experience (Singh *et al.*, 2018). Green or unripe mango contains a large amount of starch, which is gradually converted into glucose, sucrose, and maltose as the fruit ripens. The starch completely disappears when the fruit is fully ripe (Sarkinyayi *et al.*, 2013). Mangoes are also high in prebiotic dietary fiber, vitamin C, polyphenols, and carotenoids. It is an excellent source β carotene (provitamin A carotenoid) vitamin C and polyphenolic compounds with traces of vitamin E, K, and B. These bioactive compounds are good antioxidants, and their daily intake in the diet is related to the prevention of degenerative processes such as cardiovascular diseases and cancer (Tanu *et al.*, 2020). Mango is an antioxidant, so it can alleviate oxidative stress in the body. The primary benefit, in addition to being a really good source of vitamin C, is that mangoes are a good source of vitamin A, folate, and fiber, which is beneficial for colon cancer prevention, heart disease, and weight control (Elena, 2021). Elena (2021) further reported that mango fruits are packed with vitamins and minerals that are beneficial to our hearts, skin, eyes, and digestive and immune systems. Mango varies in size, shape, and color, depending on the variety, ranging from small and round to large and oval. The skin color can be green, yellow, orange, red, or a combination of these colors. Juicy flesh is typically golden yellow with a smooth texture, although some varieties may have fibrous flesh. Mangoes are known for their sweet and tropical flavor, with hints of citrus and peach. Mangoes hold cultural and culinary significance and are economically important in India. The global annual mango production is 59.65 million metric tons in which India is the leading producer with 20.77 million metric tons which accounts for more than 40% of global mango production (Statista, 2024). The Global Mango Industry plays a vital role in international trade, with mangoes being exported to various countries worldwide.

In Nigeria, mango trees have traditionally been propagated from seeds, resulting in significant phenotypic and genetic variations and producing different mango varieties throughout the country. Among the mango varieties currently known and cultivated in various parts of Nigeria are the Keith and Julie varieties. The "Keith mango" was initially reported to be a seedling of the "Mulgoba" mango, which was planted by Mrs. J. N. Keitt was born in Homestead, Florida, in 1939. The 'Keith mango is known for its large fruit size, green skin that turns yellow as it ripens, and late-season harvest, which typically extends the mango season. It is appreciated for its sweet, juicy flesh and garnered attention for its desirable traits. (University of Florida 2020)

The Julie mango is believed to have originated in the Caribbean, with a particular emphasis on Trinidad and Tobago. It is often associated with the name Saint Julian in some regions, which might reflect a local variety or a popular name in certain areas. Julie mango is known for its rich, sweet taste and unique, aromatic flavor. It typically has a small to medium size and greenish yellow skin when ripe. The flesh is vibrant yellow, smooth, and fiberless, making it particularly desirable for eating fresh (Williams, 1999).

Therefore, this study assessed the physicochemical properties of these mango varieties. The findings of this study will provide valuable information for farmers and researchers to better understand the characteristics of these mango varieties and potentially improve cultivation practices and/or market strategies for processing industries.

1. MATERIALS AND METHODS

2.1 Determination of the Physicochemical Properties of the Fresh Fruits of Keith and Julie

2.2.1 Determination of pH

The pH, an indicator of a substance's acidity or alkalinity, was measured using a digital pH meter (Model: EQ-610 Equip-Tronics) following the AOAC (2016) method. Fresh mango fruits were blended using a Kenwood blender (Philips HR 2001, China). The resulting homogenate was centrifuged at 1500 rpm for 10 min, and the supernatant was collected for use.

2.2.2 Determination of total soluble solid (% Brix)

The total soluble solids (% Brix) were determined using an Abbe Refractometer according to the AOAC (2016) method. Fresh mangoes were blended with a Kenwood blender (Philips HR 2001, China). The resulting homogenate was centrifuged at 1500 rpm for 10 min, and the supernatant was collected for analysis.

2.2.3 Determination of titratable acidity

The titratable acidity of the samples was determined according to the method described by Hussein and Filli (2018). Fresh mangoes were blended using a Kenwood blender (Philips HR 2001, China). The resulting homogenate was centrifuged at 1500 rpm for 10 min, and the supernatant was collected for analysis.

2.2.4 Determination of the maturity index

The maturity index was calculated using the formula described by Owusu *et al.* (2012).

$$Maturity\ index = \frac{total\ soluble\ solid}{titratable\ acidity} \times 100 \quad (1)$$

2.2.5 Determination of the proximate composition of dried mango

Moisture content was assessed following the AOAC guidelines (2016). Samples were dried at 105°C for 3 h in a preset oven (Fisher Scientific Isotemp Oven, model 655F, Chicago, USA). The amounts of protein (% nitrogen x 6.25) and fat were determined using the method described by AOAC (2016). One milligram of the sample was removed and dissolved in diethyl ether at 64°C. The AOAC (2016) method was used to determine the ash content. Samples that had already been weighed were placed in a Fisher Isotemp Muffle Furnace (model 186A, USA) that was heated to 600 °C for 6 h, cooled in desiccators to room temperature, and then weighed again. Carbohydrate content was calculated as the difference between 100 and the sum of moisture, protein, fat, fiber, and ash contents (AOAC, 2016).

2.3 Data Analysis

All experiments were performed in triplicate, and analysis of variance (ANOVA) was performed to determine any significant differences in measurements using SPSS statistical software (SPSS 20.0 for Windows; SPSS Inc., Chicago, IL, USA) with a confidence level of 95%. The significance of the difference between the means was determined using the least significant difference (LSD) method, and the differences were considered significant at $p \leq 0.05$.

RESULTS AND DISCUSSION

The physicochemical properties of Keith and Julie mangoes are shown in Figure 1. The initial pH, total soluble solid (TSS) content, and titratable acidity (TA) contents of the mango fruits were 3.86, 19.45 °Brix, and 0.27 g/100 g for Keith mango and 4.29, 13.90 °Brix, and 0.23 g/100 g for Julie mango, respectively. The results indicated that Keith mango had higher sugar content and lower acidity than Julie mango. The pH values obtained in this study align with the requirements for jam quality control (Brandão *et al.*, 2018) and are similar to the pH range of 4.35–4.71 found in mango cultivars from Bangladesh (Ara *et al*., 2014). The total soluble solids found in this study were also between 12.87 and 21.05% (Ara *et al.*, 2014), 17.31 and 20.75% (Ubwa *et al.*, 2014), and 14.5% and 30.0% (Othman and Mbago, 2009), which are all in the range of mango fruits. TSS is an index used to determine fruit maturity and a strong indicator of the appropriate harvest time. TSS content is directly related to fruit acidity, with acidity decreasing and TSS increasing as the fruit matures and ripens (Sajib *et al*., 2014). The differences observed between TSS and TA in this study may be attributed to cultivar variation. Rahman *et al*. (2010) highlighted the significant effect of cultivar differences on TSS content. Akin-Idowu *et al*. (2020) emphasized that TSS, pH, and shelf life are crucial parameters in mango breeding programs because they significantly contribute to mango quality.

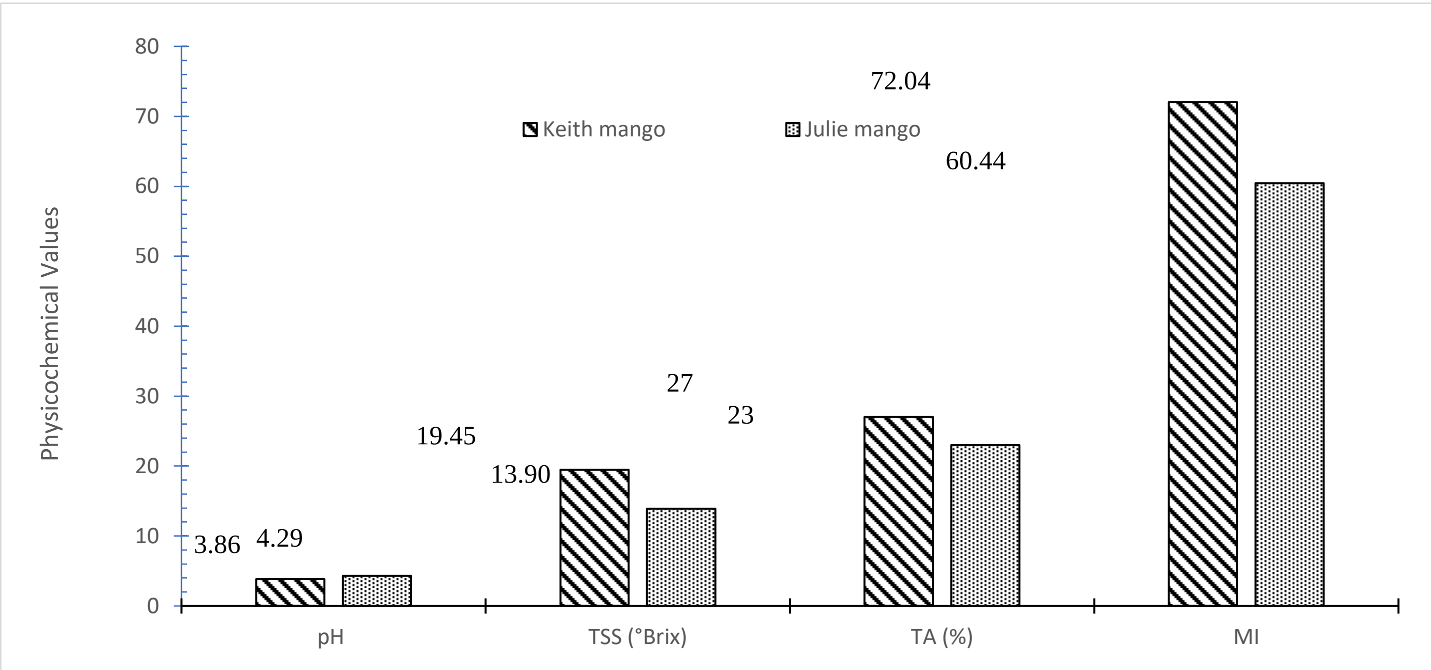

Fig. 1: Physicochemical Properties of Keith and Julie Mangoes.

Where TSS is total soluble solid, TA is titratable acidity, MI (Maturity index).

The maturity index of Keith mango was 72.04, and that of Julie mango was 60.44. These values corroborated the range of 62.00 to 69.40 reported by Obasi (2004) for the Julie and Peter mango varieties. The maturity index is an important indicator of the optimal harvesting time for mangoes, ensuring that the mangoes are at their peak ripeness before consumption or processing. The results suggest that Keith mango may be more suitable for fresh consumption due to its higher sugar content, whereas Julie mango may be better suited for processing due to its lower acidity. On the other hand, Coral and Escobar-Garcia (2021) reported that the low total soluble solid content in mango fruits might be the reason for their recommendation to people with insulin resistance or diabetes.

The proximate compositions of fresh Keith and Julie mango fruits from the first and second years of the experiment are presented in Table 1. The assessment of moisture content is one of the most crucial analyses performed on food products because it directly affects their quality. Higher moisture content increases the susceptibility of a product to spoilage due to microbial activity (Seema, 2015; Akin-Idowu *et al*., 2020). Results of moisture in the first year indicated a highly significant difference ($P \leq 0.01$) existed among the varieties (Table 1). In the first year, the Julie variety had 83.85% moisture content, which differed significantly ($P \leq 0.01$) from the 79.30% recorded by the Keith variety. During the second year, however, there were no significant difference ($P \geq 0.05$) among the varieties in terms of percentage moisture content. The moisture content found in this study is similar to the results of 77.4%–78.70% for certain mango cultivars as reported by Abdualrahm (2013), 77.85–82.22% as reported by Ubwa *et al*. (2014), and 74.58–86.36% reported by Uddin *et al*. (2006). According to Ueda *et al*. (2000), most fruits contain 70%–90% water, which is consistent with the range obtained in this study. In this study, both varieties exhibited high moisture content, suggesting they are likely to have a short shelf life and limited stability. These findings highlight the importance of proper storage and handling of mango fruits to maintain fruit quality.

Regarding the protein content of fresh mango fruit, there were highly significant differences (P≤0.01) among the varieties, with variety Julie recording a higher protein content value of 0.70% in both years (Table 1). The variety Keith had 0.12% and 0.28% protein content in the first and second years, respectively. These findings suggest that there are significant variations in protein content among the two mango varieties, with Julie exhibiting higher protein levels than Keith.

Table 1: Proximate Compositions of Fresh Keith and Julie Mango Fruit Varieties from First to Second Year Cropping Seasons.

Treatment	Moisture content (%)	Protein content (%)	Fat content (%)	Ash content (%)	Fiber content (%)	Carbohydrate content (%)	Dry matter content (%)	Energy content (%)	Vitamin C content (mg/100g)
First Year									
Keith	79.30	0.13	0.03	0.62	0.61	19.30	20.70	63.35	47.33
Julie	83.85	0.70	0.94	0.96	0.20	13.30	16.15	64.79	55.00
P≤F	≤0.001	≤0.001	≤0.001	0.018	≤0.001	≤0.001	≤0.001	≤0.001	≤0.001
LSD	0.574	0.086	0.022	0.243	0.05	0.654	0.574	2.338	1.851
Year Second									
Keith	84.00	0.28	0.62	0.67	0.26	14.17	16.00	63.35	49.61
Julie	83.67	0.70	0.95	1.11	0.21	13.36	16.33	64.79	52.87
P≤F	1.19	≤0.001	0.003	0.206	0.12	0.016	0.48	0.239	0.001
LSD	1.19	0.129	0.146	0.817	0.12	0.563	1.19	2.895	1.039

In the first year, the percentage fat content in fresh mango fruits was observed to be highly significant (P≤0.01) between the two varieties. Variety Julie recorded the highest fat content at 0.94%, which differed significantly different (P≤0.01) from variety Keith, which had a fat content of 0.03% of fresh mango fruits. In the second year, a highly significant (P≤0.01) difference was observed among the varieties in terms of percentage fat content. The Julie variety had a 0.95% fat content, which differed significantly (P≤0.01) from the 0.62% fat recorded by the Keith variety (Table 1). The difference in fat content percentage between the two varieties could be attributed to genetic differences.

The crude fat content found in this study is consistent with the 0.20% reported for Dodo mango in Tanzania (Othman and Mbago, 2009), the 0.29–0.38% reported by Abdualrahm (2013) for various mango cultivars, and the 0.13%–1.20% reported by Ara *et al*. (2014) for other mango varieties. According to Marles (2017), the crude fat content of different fruits is typically not greater than 1.0%. These findings suggest that the crude fat content of mango is consistent with that of other fruits. mangoes are generally low in fat. As a result, given their low levels of crude fat, these mango varieties are poor sources of fat.

Ash content in food refers to the inorganic residues remaining after ignition or complete oxidation of organic matter, indicating mineral content in the food (Akin-Idowu *et al*., 2020). In the first year, the percentage content of ash in fresh mango fruits was observed to be significant (P≤0.05) among the two varieties. Variety Julie recorded a higher ash content (0.96%) compared to variety Keith, which had a 0.62% ash content of fresh mango fruits. In the second year, there was no significant (P≤0.05) difference observed among the varieties in terms of percentage ash content. This indicates that the ash content of fresh mango fruits may vary among varieties. For fiber content in the first year, a highly significant (P≤0.01) difference was observed among the varieties (Table

1). Variety Keith recorded 0.61% fiber content in fresh mango fruit, which differed significantly (P≤0.01) from variety Julie, which had 0.21% fiber content. In the second year, there was no significant difference (P≤0.05) among the varieties in the percentage fiber content of fresh mango fruit among the varieties. These results were lower than the range of 0.11%–0.18% reported by Ernesto *et al.* (2017) and 0.47 % reported by Mohammed *et al.* (2017) for the Keith mango variety. The differences observed could be a result of varietal factors, soil characteristics, cultural practices, growing conditions, and climate.

The crude fiber content showed significant differences (P≤0.01) among the varieties in both the first and second years. In the first year, the Julie variety had higher fiber content of 2.74%, which was significantly higher than the Keith variety (1.44%. In the second year, the Julie variety had a significantly higher fiber content (P≤0.01) at 2.75% compared to the Keith variety, which had 1.82%. These results are similar to the 0.84%–1.11% fiber content reported for mango cultivars by Ubwa *et al*. (2014) and the 0.85%–0.87% reported for some Tanzanian mango varieties by Othman and Mbago (2009). However, these values are lower than the 3.7% reported by Mamiro *et al*. (2007) and the 4.2%–4.5% reported for some mango cultivars by Abdualrahm (2013).

In the first year, there were highly significant differences (P≤0.01) among the varieties in the percentage of carbohydrate content of fresh mango fruit samples. The Keith variety with 19.31% carbohydrate content differed significantly (P≤0.01) from the 13.34% carbohydrate content recorded by the Julie variety. Similarly, during the second year, the results showed that a significant difference (P≤0.05) did exist among the varieties in the percentage of carbohydrate content of the fresh mango fruit samples. The 13.36% carbohydrate percentage of the Julie variety was significantly lower (P≤0.05) than the 14.17% carbohydrate percentage recorded for the Keith variety. These findings suggest that there are significant variations in carbohydrate content among different mango varieties, which could impact consumer preferences and nutritional value.

In the first year, a highly significant difference (P≤0.01) among the varieties (Table 1). The Julie variety recorded 16.15% dry matter content, which differed significantly (P≤0.01) from the 20.70% recorded by the Keith variety. During the second year, however, the result showed that no significant difference (P≥0.05) among the effects of variety on dry matter percentage was observed. Regarding energy value in the first year, a highly significant (P≤0.01) difference was observed among the varieties of fresh mango fruit. Variety Keith recorded a 78.04% energy value for fresh mango, which differed significantly (P≤0.01) from variety Julie, which had a 64.62% energy value. In the second year, there was no significant difference (P≤0.05) among the varieties in the percentage energy value of fresh mango fruit (Table 1). The percentage energy value of fresh mango fruit remained consistent across the two varieties throughout the second year.

From Table 1, in the first year, there were highly significant differences (P≤0.01) among the varieties in the percentage of vitamin C content of fresh mango fruit samples. The Julie variety with 55.00 mg/100g vitamin C content differed significantly (P≤0.01) from the 47.33 mg/100g vitamin C content for the Keith variety. The same pattern was observed in year 2. It is important to consider these differences when selecting mango varieties for consumption or commercial use.

The vitamin C content found in this study was similar to the 6.04–11.23% reported for three mango varieties (Ubwa *et al*., 2014) and comparable to the 5.1–25.2% observed in some mango cultivars (Othman and Mbago, 2009).. The fruit pulps used in this study meet the minimum vitamin C requirements of 15 mg/100 g and 80 mg/100 g recommended by NAFDAC (2013) for fruit groups. These findings highlight the nutritional value of the fruit pulps analyzed in this study, providing a significant source of vitamin C that can contribute to overall health and well-being. Including these fruits in a balanced diet can help individuals meet their daily vitamin C and bodily functions.

2. CONCLUSION

The results of this study indicate that these mango cultivars are diverse and provide valuable genetic resources for mango improvement through breeding. Significant differences in physicochemical composition were observed among the mango cultivars, suggesting some degree of variation. This finding highlights the genetic diversity of the physicochemical composition of the cultivars. By leveraging this diversity, breeders can develop mango varieties that are not only high-yielding but also possess desirable nutritional traits. This approach could ultimately contribute to the sustainable development of the mango industry in Nigeria and potentially lead to increased market competitiveness.

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