ID: 654

Nutritional Composition of Hass Avocado (*Perseaamericana* Mill) Cultivated in Major Growing Areas in Kenya

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Abstract

Avocado is an important horticultural crop in Kenya and a key export fruit. The quality of avocado fruit is influenced by numerous environmental factors such as soil composition, elevation, rainfall, temperature, and sunlight exposure, alongside crop husbandry, postharvest handling, and geographical origin. Avocado samples from these regions were analysed for proximate composition, including ash, protein, lipid, fibre and carbohydrates, and fatty acid composition of extracted oils.

Findings revealed marginal variations across the regions. In terms of weight, samples from Nandi were the highest with 231.85 ± 0. 84g, followed by Kisii (219.52 ±0.59g), Muranga (165.02 ±0.94g) and Nakuru (149.20 ±1.35g), respectively. Moreover, samples from Murang'a recorded the lowest pulp yield (62.28%) and the highest seed proportion (23.08%), while other regions showed an insignificant difference in pulp content (71.33%) and seed (14.48%). The pulp content of Murang'a and Nandi regions exhibited the highest fat content at 68.26±3.18% (dwb) and 64.22±0.93% (dwb), followed by Kisii at 60.84±0.31 % (dwb). Nakuru had the lowest lipid content at 45.91% (dwb). Samples from Kisii had higher ash content (6.79% dwb), those from Murang'a had elevated fibre (4.46% dwb), while samples from Nakuru exhibited higher protein (7.63%dwb) and carbohydrate (36.61% dwb) levels. The fatty acid composition of avocados was in the range of oleic acid 55.1-60%, followed by Palmitic acid 22.1-23.8%, Linoleic was 18.8-21.1%, with saturated/unsaturated ratio in the range of 0.27-0.31, implying healthy fatty acid profiles for human nutrition for all the samples. Generally, the quality of the study samples was comparable to those traded globally in terms of nutrient profile.

Overall, Kenyan Hass avocados meet the required export quality in terms of size (calibre), pulp-to-seed and peel ratio was within acceptable limits, the nutritional composition of avocados and their lipid content is in line with those reported in key avocado-producing and exporting countries.

Keywords: *Hass avocado; proximate composition; Fatty Acid profile; lipid quality; Kenya*

Introduction

Avocado consumption has increased globally over the past years due to its recognised nutritional benefits, particularly its rich content of monounsaturated fatty acids (MUFAs), protein, vitamins, minerals, and dietary fibre (Acosta-Díaz et al., 2019; Carvajal-Zarrabal et al., 2014). The fruits are a good source of folate, potassium, healthy fats, and vitamins K, C, and E, and also contain small amounts of B vitamins and minerals, such as copper, phosphorus, magnesium, manganese, iron, and zinc (Ford et al., 2023). The monounsaturated fats in avocados, most of which are oleic acid, are good for heart health, fight inflammation, and may have anticancer properties (Carvalho & Velásquez, 2015; Méndez Hernández et al., 2023)

Kenya is a significant player in avocado production and export and is currently ranked 5th in avocado production after Mexico, Colombia, Peru and the Dominican Republic (FAO, 2024). In 2018, for instance, a total of 318,087,000 kgs of avocado fruit was produced in Kenya, with the Central region accounting for 54.4%, Eastern (9%), Western (3.3%), Rift Valley (7.4%), Nyanza (21%), Coast (2.9%) and Nairobi (2%). The major avocado-producing counties in Kenya are Murang'a (42%), Kiambu (11%), Kisii (7%), and Nyamira (5%), while Bomet, Embu, Meru and Bungoma account for 3% each (MoALFD, 2020). The country is ranked 6th in avocado export globally and 1st in Africa. Moreover, Kenya is ranked 3rd after Israel and Mexico among avocado exporters to the European market, with the Netherlands, U.A.E., France, UK, and Saudi Arabia being the five largest importers of Kenyan avocados (MoALFD, 2020).

The main avocado varieties grown in Kenya are Hass (20%) and Fuerte (80%) for the export market and Puebla, Duke and G6 for the domestic market (Mellado& Ferrari, 2019). Hass avocado is regarded as the most important in terms of cultivated area, geographical distribution and consumption(Cruz-lópez & Caamal-cauich, 2022; USDA, 2018). It is the most popular export variety because it enjoys a big market in Europe and other destinations compared to the other varieties (Kathula, 2021). Moreover, the variety has gained particular prominence due to international demand fuelled by its perceived health benefits, unique flavour and extended shelf life (Nyakang'i et al., 2023).

While avocado export is key to Kenya, the sector faces myriad challenges; hence, many harvested fruits do not meet export quality standards. Approximately 45% of the fruits are not export quality and provide raw materials for oil extraction. Avocado oil processing is enjoying phenomenal growth in Kenya and provides a growing market opportunity for Grade 2 avocados unsuitable for export or sale in the domestic fresh fruit market (USAID, 2018). Domestic demand for Kenyan avocados accounts for more than 80% of total production, with the remainder exported as fresh fruits or processed and exported as crude oil (Kathula, 2021).

The quality of avocado fruit is influenced by numerous environmental factors, such as crop husbandry, postharvest handling, and geographical origin (Juan Camilo et al., 2019). Varied soil composition, elevation, rainfall, temperature, and sunlight exposure create distinct micro-environments influencing nutrient uptake by avocado trees, impacting the accumulation of essential nutrients, antioxidants, and bioactive compounds in the fruit (Kenbon Beyene, 2017; Ramírez-Gil et al., 2019). Such disparities can lead to differences in macronutrients, micronutrients, and antioxidants in avocados, with those grown in favourable environments offering enhanced nutritional quality and potential health advantages for consumers. Moreover, regional disparities may also influence the taste, flavour, and texture of fruits and can be attributed to differences in the composition of sugars, organic acids, and volatile compounds (Mccarthy & Considine, 2008). The sensory attributes and nutritional composition contribute to consumer preferences and market demand for avocados.

Previous research has delved into several aspects relating to avocados. For instance, a study in Egypt (Rozan et al., 2021) examined various avocado varieties' chemical composition, bioactive compounds, and antioxidant activity. Another study conducted in Malaysia focused on the proximate composition and physical properties of Thompson red avocado fruit (Tan et al., 2022). In Colombia, Henao-Rojas et al. (2019) explored the influence of different growing regions on avocado quality. In Kenya, research on the total phenolic content of avocado seeds was reported (Githinji et al., 2013), but studies profiling its nutritional composition are largely lacking despite Hass avocado's significance in the country. Furthermore, the influence of different growing regions on the nutritional composition of Hass avocado remains unexplored. Existing studies have suggested that climate and ecological variations, including geographical location and agricultural practices, can affect avocado composition, highlighting the necessity to evaluate this aspect concerning Hass avocados in Kenya.

Avocado is consumed in various forms in Kenya and globally, as puree salads, juice, seasoned with salt. Avocado pulp contains from 67 to 78% moisture, 13.5 to 24 % lipids, 0.8 to 4.8% carbohydrate, 1.0 to 3.0% protein, 0.8 to 1.5% ash, 1.4 to 3.0% fiber, and energy density between 140 and 228kcal (Duarte et al., 2016). Avocado

The country’s diverse regions exhibit significant geographical and climatic variations, which profoundly affect the growth of crops (Henao-Rojas et al., 2019; Kathula, 2021; Nyakang'I et al., 2023). This study aims to investigate and compare Hass avocados' nutritional composition and fatty acid profile from major producing regions in Kenya.

Materials and Methods

Study site

The study was conducted in Murang'a, Nakuru, Kisii, and Nandi Counties of Kenya. Among these, Murang'a County was the primary contributor to avocado production, accounting for 31% of the total value of Kenya's top 10 avocado-producing regions. This percentage represents the broader Central Kenya counties engaged in avocado cultivation. Kisii follows, with 6.8%, representing regions in Nyanza and South Rift involved in avocado production. Nakuru produced 6.8%, representing the avocado-producing counties in the Central Rift Valley.

Meanwhile, Nandi County contributes 2.7%, representing Western Kenya and North Rift in avocado cultivation. These counties lead in their regional avocado production in Kenya. Furthermore, the combined avocado production from these counties accounts for 47.9% of the national avocado production in value (MoALFD, 2020).

Study Design

A quantitative descriptive comparative study design was employed for the investigation. This design enabled the simultaneous collection and assessment of data across multiple distinct avocado growing areas within Kenya.

Sample collection

Representative samples of Hass avocado were collected from the study regions, with four avocado farms selected per county to represent each area. Only farms with Global GAP Certification were selected in the study. One hundred sixty (160) mature Hass avocados were randomly collected from different trees within the farms based on Codex standard 197-1995. The selection criteria ensured uniformity in maturity, size, and the absence of visible defects among the avocados. All samples were transported to Kenya Industrial Research and Development Institute (KIRDI) and Spectre Laboratories under controlled temperature and humidity conditions to maintain freshness and integrity. Ripening of the avocados was conducted at 20°C, and sample analyses were performed when the avocados ripened.

Sample preparation

The sample preparation involved cleaning and careful extraction of pulp, seed, and peel from the Hass avocado obtained from each region. The samples were carefully washed and then split to access the pulp, seed, and peel.

The peel, pulp and seeds were manually separated, with the seeds extracted and cleaned. Subsequently, each farm's pulp, seed, and peel were aggregated separately to form representative samples. The aggregated components were weighed and prepared for analysis. The fruit parts were cut into smaller pieces and dried in an oven dryer (Memmert, Germany) for three days at 45 ºC. The dried fruit parts (moisture content 9%) were ground into powder using a home blender (Waring MX1500XTX, USA). The powdered samples were stored in airtight plastic containers at -20 ºC until further analysis.

Mass and calibre of fruits

The whole fruits and fruit parts (peel, pulp, and seeds) were weighed using a digital balance (Shimadzu AUW220D, Japan), and the results were expressed as a percentage of total mass.

Proximate Composition Analysis

The proximate composition analysis was carried out to assess the nutrient content of the avocado samples. This analysis encompassed the quantification of essential components, including carbohydrates, proteins, calorific value, total ash content, fibre, and fats, employing established standard analytical methods outlined by the AOAC (Association of Official Analytical Chemists). Total ash content was assayed by placing the sample in a muffle furnace at 550°C for 8 hours (AOAC 942.05, 2012). The protein content was evaluated using the Kjeldahl method (N x 6.25) (AOAC 960.52, 2012), while crude fibre content was quantified following the AOAC method 2009.01, and fat content determined by solvent extraction method (AOAC 2003.06-2012) (AOAC, 2012). Carbohydrate content was obtained by difference, involving the subtraction of the combined weights of moisture, protein, fat, ash, and fibre from the total sample weight. The data obtained were expressed as percentages on a dry weight basis (dwb).

Fatty Acid Composition Analysis

Near-infrared (NIR) spectroscopy was employed to analyse lipid profiles. This method harnesses the near-infrared region of the electromagnetic spectrum, spanning approximately 700 to 2500 nanometres. By assessing the light interactions involving a sample, NIR reflectance spectra can swiftly unveil the material's properties without requiring sample modification. This approach is facilitated by the fact that NIR absorption bands, at wavelengths around 1600–1800 nm and 2100–2200 nm, correspond to distinct features in the molecule, specifically the straight carbon chain and double bonds, respectively.

Statistical Analysis

The data collected were analysed to obtain means and standard deviation for avocado samples from selected regions in Kenya. Analysis of variance (ANOVA), followed by a post-hoc test, was conducted to establish significant differences ($p < 0.05$) among samples from different regions. Data was analysed using GraphPad Prism 8 (GraphPad Software, Boston, MA-USA).

RESULTS AND DISCUSSION

Hass avocado calibre and weight of fruit and fruit parts from selected regions in Kenya

The weight of Hass avocado fruit samples exhibited varied results depending on the sampled region, as shown in Table 1 below. Fruit samples from Nandi were the heaviest with an average weight of 231.85 ± 0. 84g, followed by Kisii (219.52 ±0.59g), Muranga (165.02 ±0.94g) and Nakuru (149.20 ±1.35g), respectively. Based on calibre ranking, the Hass avocado samples from Murang’a had a calibre of 24, while Nakuru, Kisii and Nandi recorded values of 26, 18 and 16, respectively. This grading system is based on United Nations Economic Commission for Europe (UNECE) criteria for size (calibre) grading used by avocado producers and exporters, with European Union (EU) buyers preferring a calibre range of 16 (227g to 274g) to 20 (184g to 217g) (UNECE, 2019). Based on this criterion, samples from Nandi and Kisii fall within the acceptable range and hence qualify for export to Europe, while Muranga and Nakuru were not within the preferred levels.

Such variability in the weight of Hass avocado fruit has been observed in previous studies (Carvalho et al., 2014; López-Pimentel et al., 2022), where avocados from orchards in high-altitude areas had higher weights and sizes than those from lower-altitudes. Nandi and Kisii regions sit at higher altitudes (up to 2062mtrs and 2190mtrs, respectively) than Nakuru and Murang'a (1912mtrs and 1665.06mtrs, respectively). Other than altitude, factors such as soil fertility, climatic conditions and agricultural practices have also been attributed to variations in fruit sizes/weights (Henao-Rojas et al., 2019).

Table 1. Calibre and Mean weight of avocado fruit, peel, pulp and seed from selected regions in Kenya. Weight data indicates the Mean ±SD of triplicate samples.

County	Calibre	Fruit weight (g)	Pulp weight %)	Seed weight (%)	Peel weight (%)	Pulp/Seed
Muranga	24	165.02 ±0.94	62.71±0.43	22.83±0.23	13.75±0.23	2.75
Nakuru	26	149.20 ±1.35	70.87±0.24	14.32±0.22	15.41±0.26	4.95
Kisii	18	219.52 ±0.59	70.93±0.08%	16.02±0.11	13.38±0.14	4.43
Nandi	16	231.85 ± 0.84	72.66±0.16	13.61±0.175	14.00± 0.07	5.33

The percentage (%) pulp content of Hass avocado from Muranga, Nakuru, Kisii and Nandi were 62.71±0.43%, 70.87±0.24%,70.93±0.08%, and 72.66±0.16%, respectively, while the seeds accounted for 22.83±0.23%, 14.32±0.22%, 16.02±0.11%, and 13.61±0.18%, respectively. The proportion of peel, on the other hand, was 13.75±0.23%, 15.41±0.26%, 13.38±0.14%, and 14.00± 0.07%, respectively. From the results, fruits from Murang'a exhibited the lowest pulp percentage of 62.71±0.43%, compared to Nandi, which recorded the highest pulp percentage, 72.66±0.16%, while Nakuru and Kisii had no significant difference. The pulp percentage difference between the regions differed significantly (p<0.05), with Muranga recording a significantly lower value than the other counties. Conversely, Murang'a also showed the highest seed percentage, 22.83±0.23%, compared to the other regions, which were between 13.61±0.18and 16.02±0.11%. The seed percentage difference between the regions was significantly different (p<0.05). All the regions exhibited relatively similar peel percentages (Kisii 13.38±0.14%, Murang'a13.75±0.23%, Nandi 14.0±0.07%, and Nakuru 15.41±0.26 %, with samples from Nakuru being significantly higher than from the other regions (p<0.05). Murang'a origin avocados exhibited the lowest pulp and highest seed percentages, making them less desirable than those from Nandi, which had high pulp and low seed percentages. The observed differences can be attributed to environmental factors such as microclimate, soil fertility, climate conditions, and possibly agricultural practices specific to each region.

The present findings on pulp percentage largely fall within that was reported by (Alnasan et al., 2019), who found that Hass possesses a pulp content ranging from 67.96% to 85.3%, with Hass avocado having 67.96% in Hass, and Fortuna cultivars having 85.3% pulp content. Another study reported that avocado pulp represents between 52.9 and 81.3% of the fruit mass (Jimenez et al., 2021), while all the Hass avocados sampled in the present study fall within the range. Meanwhile, seed and skin/peel comprise about 33% of the total fruit weight (Dreher & Davenport, 2013). It was reported that, on average, an avocado fruit consists of the peel (7–15%), the pulp (65–73%), and stone (including the seed) (14–24%) (García-Vargas et al., 2020). It was reported that avocado fruits with lower seed and peel levels are most interesting for oil extraction due to their higher pulp yield (Domínguez et al., 2016). A study in Ethiopia by Tesfaye et al. (2022) established that the avocado seed represents 13–18% of the fruit, similar to our findings. Further, the seed and peel content of Hass are notably lower, making it suitable for various home consumption and guacamole and industrial applications like oil extraction. The pulp to seed ratio of avocados from Muranga, Nakuru, Kisii and Nandi were 2.75, 4.95, 4.43, and 5.33, respectively. The higher the pulp-to-seed ratio, the higher the avocado pulp yield. The distinctive proportions of seed, pulp, and peel in the Hass avocado contribute to its culinary versatility and commercial success, underscoring its significance in the avocado market. In a study reported on the Hass avocado from Ethiopia, it was established that the Hass avocado cultivar showed a greater flesh-to-seed ratio (13.57±10.43) and had a lower fruit weight (183.92±47.58g) (Kenbon Beyene, 2017).

Proximate composition of Hass avocado pulp from selected regions in Kenya

The results of the proximate composition of Hass avocado pulp are shown in **Hata! Başvuru kaynağı bulunamadı.** below. The data showed non-significant variation in the nutritional composition of the avocado pulp between the proximate parameters except for fats (% w/w) dwb and carbohydrates (% w/w) dwb. No statistically significant differences were observed at ($p < 0.05$) level. Avocados from Kisii exhibited the highest ash content of 6.79±0.53% (dwb), suggesting superior mineral content. Conversely, avocados from Nakuru demonstrated the highest protein and carbohydrate content at 7.63±0.85% (dwb) and 36.611±0.46% (dwb), respectively. In contrast, avocados from Murang'a displayed elevated fat and fibre levels, with values of 68.26±3.18% (dwb) and 4.46±0.32% (dwb), respectively.

Fat and carbohydrate content exhibited the highest levels among the proximate parameters analysed, a finding consistent with the established nutritional profile of Hass avocado (Jimenez et al., 2021). Notable parameter variations were observed among the regions, with statistically significant differences ($p < 0.05$) in lipids and carbohydrates. Specifically, Murang'a and Nandi regions exhibited the highest fat content at 68.26±3.18% (dwb) and 64.22±0.93% (dwb), respectively, whereas the lowest lipid content was reported in the Nakuru at 45.91% (dwb), and Kisii 60.84±0.31 % (dwb). Carbohydrate content for Murang'a had the lowest levels at 13.67±2.64% (dwb), contrasting with Nakuru, which displayed the highest at 36.61±0.46% (dwb). Kisii and Nandi regions reported intermediate carbohydrate levels at 21.49±0.31% (dwb) and 19.67±1.22% (dwb), respectively.

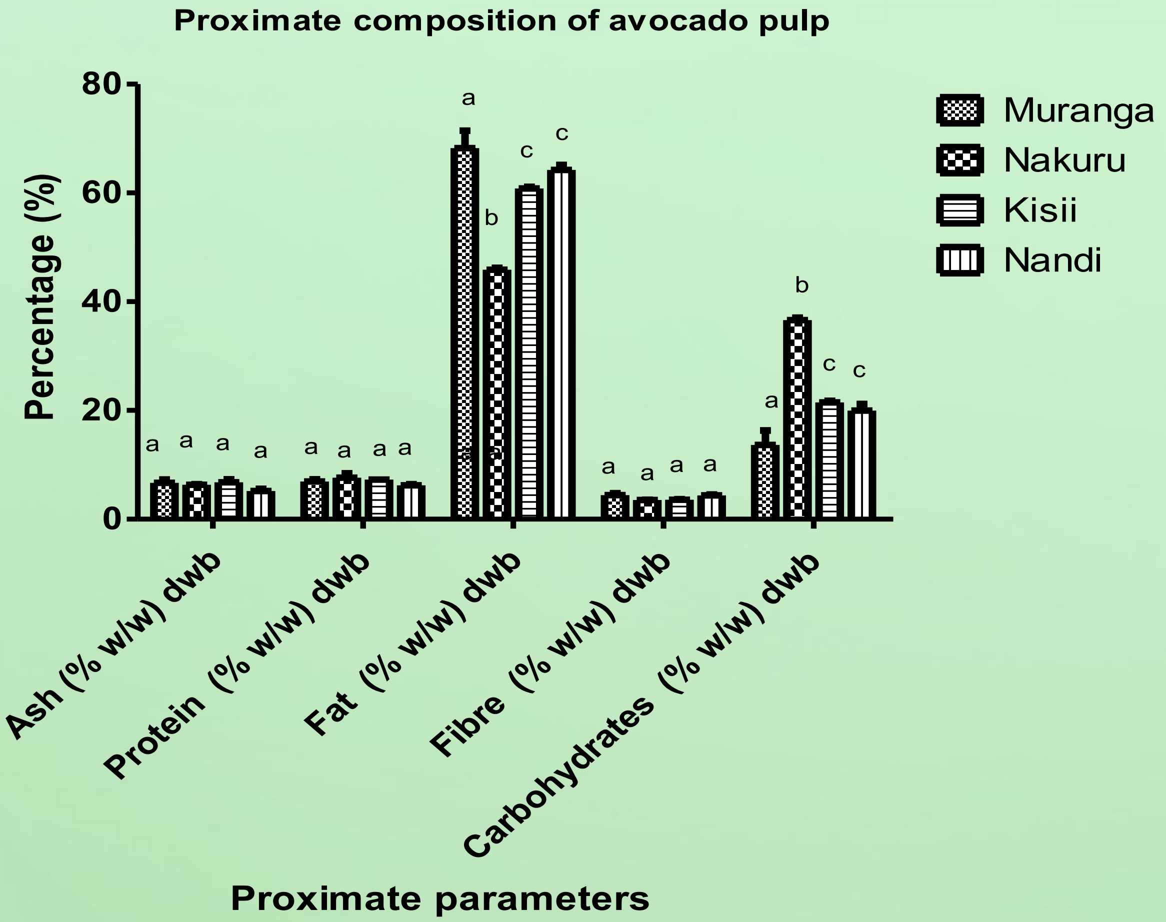

Figure 1.The Proximate composition of Hass avocado pulp. Each data point represents the mean±SD of triplicate samples. Bars with similar letters are not significantly different, while those with similar letters are significantly different at $p < 0.05$.

The avocado pulp contains high lipids content, which makes the pulp the portion of greatest interest. Avocados are among the fruits with the highest fibre content, including 75% insoluble and 25% soluble fibre (Araújo et al., 2020; Noorul et al., 2016). It was reported that the relative amount of pulp varies according to cultivar, from 67.96% in Hass to 85.3% in the Fortuna cultivar. The oil content may also vary widely (13.15% in Margarida to 25% in Hass) by soxhlet extraction and (7.9% in Margarida to 20% in Hass) by cold-centrifugal (Alnasan et al., 2019). A study on Mexican avocado pulp reported the following values: carbohydrates (4.2–5.6%), proteins (1.2–1.8%), dietary fibre(12.55–15.8%), and lipids (12– 16%) on a wet weight basis (Méndez-Zúñiga et al., 2019). Other studies report moisture content ranging from 67 to 78%, lipid content ranging from 12 to 24 %, carbohydrate content ranging from 0.8 to 4.8%, protein content ranging from 1.0 to 3.0%, ash content ranging from 0.8 to 1.5%, fibre content ranging from 1.4 to 3.0%, with energy of between 140 and 228 kcal per avocado on wet weight basis (Duarte et al., 2016).

Fatty Acid profile of Hass Avocado from selected regions in Kenya

The oleic content of Hass avocado was in the range of 55.1-60%, followed by Palmitic acid 22.1-23.8%, Linoleic was 18.8-21.1%, with only Nandi origin samples having trans fatty acid in negligible level of 2% as, while the Linolenic and stearic acids were largely below the detection limit per Figure 2 the results within the range of reported values for Mexican avocados (Méndez-Zúñiga et al., 2019). Moreover, the results largely conform to the proposed Codex Standard for avocado oil profile, which specifies that Palmitic acid C16:0 is 11.0–26.0%, Linoleic acid C18:2 (7.8–19.0%), Oleic acid C18:1(42.0–75.0%), and C18:3 Linolenic (0.5–2.1 %) (Green & Wang, 2023). A study on 68 avocado oil samples in the USA found the following values: C16:0 9.90–23.19%, C16:1 3.32–10.03%, C18:1 49.74–71.41%, and C18:2 9.25–22.46% (Green & Wang, 2023). According to a study by Méndez Hernández et al. (2023), the fatty acid profile of avocado is within the following arrange: oleic acid represents 50–60% of the total fatty acids, followed by palmitic (15–20%), palmitoleic (6–10%), linoleic (11–15%), and linolenic (1%) acids. Thus, monounsaturated fatty acids dominate the composition of avocado oil, especially oleic acid. A study to determine the effect of altitude on orchards of avocados found that the quantities of oleic acid decreased drastically at lower altitudes while the amounts of palmitoleic and linoleic acids increased (Carvalho & Velásquez, 2015). Therefore, this can explain slight variations in amounts across the sampled regions. Another study found that exposure to the sun increased the proportion of the saturated fatty acid palmitic acid and decreased the proportion of monounsaturated fatty acid oleic acid (Woolf et al., 1999). Palmitic acid levels were the highest of the saturated fatty acids in all samples, ranging from 38.37% to 48.32% of the total lipid. The oleic acid content in all avocado cultivars was higher than those of other unsaturated fatty acids. It was further revealed that early and late-harvested fruits showed higher total lipid content than the rest (Teng et al., 2016). Moreover, a study of 12 native Mexican avocado accessions found that the primary saturated fatty acids in all the avocado accessions were palmitic acid (15.54-22.68%), monounsaturated fatty acids (oleic) (56.58-74.19%) while polyunsaturated fatty acids were linoleic (5.62-16.85%), and linolenic (0.63-2.85%) being the most abundant unsaturated fatty acids in all the accessions (Méndez-Zúñiga et al., 2019). Researchers in Colombia determined that at a higher elevation, the concentration of fatty acids in avocados increases (Ramírez-Gil et al., 2019).

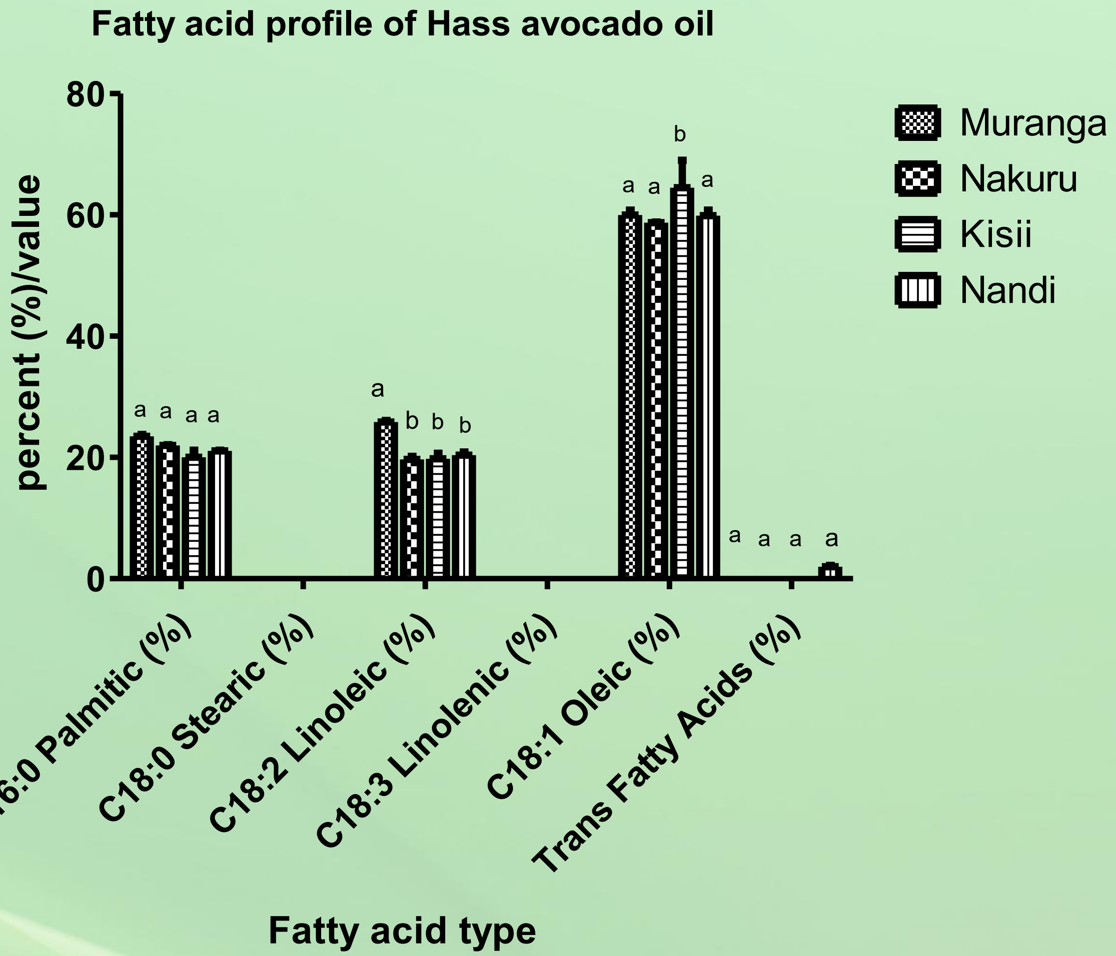

Figure 2. Fatty acid profile of Hass avocado oil. Each data point represents the mean±SD of triplicate samples. Bars with similar letters are not significantly different, while those with similar letters are significantly different at $p < 0.05$.

Previous publications reported Hass avocado pulp composition to be as follows: oleic acid (18:1n-9) (about 59%), Palmitic acid (16:0) (approximately 14%), linoleic acid (18:2n-6) is the predominant polyunsaturated fatty acid (approximately 11%) (Ford et al., 2023). The fatty acid profile is influenced by ripening, where during ripening at 20 ◦C, palmitic acid content decreases and polyunsaturated fatty acids increase, while monounsaturated fatty acids remain relatively unchanged. However, pre-harvest conditions may influence fatty acid profiles because lower growing temperatures shift the oil profile towards more oleic acid and less palmitic acid (Ferreyra et al., 2016; Ozdemir & Topuz, 2004). These regional fat and carbohydrate content disparities may be linked to origin, season, and production practices (Rodríguez et al., 2023).

It was reported that harvesting time affects the lipid content of avocado fruit. Early and late-harvested fruits showed higher total lipid content than others (Teng et al., 2016). The MUFAs essentially consist of Oleic acid, the predominant monounsaturated fat in avocado oil, making up approximately 60-70% of the total fatty acids. Oleic acid is a heart-healthy fat that has been associated with various health benefits. Meanwhile, for saturated fatty acids, palmitic acid is the primary saturated fat found in avocado oil, comprising around 15-20% of the total fatty acids. Of the polyunsaturated fatty acids (PUFAs), Linoleic, an omega-6 fatty acid, is the primary constituent but occurs in low amounts in avocado oil. However, the exact proportion may vary. It is important to note that the specific fatty acid composition can differ slightly based on factors such as avocado variety and growing conditions. However, Hass avocados from Mexico, one of the major producers of avocados globally, generally exhibit a similar fatty acid profile (Rodríguez et al., 2023). Oil may be classified as hard or soft, depending on the ratio of saturated to unsaturated fatty acids. Soft oils are defined as liquid oils containing a very high percentage of unsaturated fatty acids, while hard oils contain high levels of saturated fatty acids (Naghshineh et al., 2010).

Table 2.The Fatty acid quality of Hass avocados from the four (4) main avocado-producing regions in Kenya.

Region	Total saturated fatty acid	Total Saturated fatty acid	Saturated/Unsaturated fatty acid ratio
Muranga	23.8	76.2	0.31
Nakuru	22.1	77.9	0.28
Kisii	21.2	78.8	0.27
Nandi	21.2	78.8	0.27
Average value			**0.28**

The desirable ratio is between 0.1-0.44, with lower values representing the best oil/fat quality. This signifies that the fatty acid profile of the Kenyan avocado is healthy, with samples from Kisii and Nandi having the best ratio. The values of Kenyan Hass avocado oil were within the range reported for various avocado-producing countries as per a study report on the saturated/unsaturated ratio reported that Australia 0.35, Mexico 0.29, New Zealand 0.26, USA 0.30, and Colombia 0.2 (Ramírez-Gil et al., 2019). The findings are within the ratios reported in avocados from Morocco, where Hass avocado oil was rich in oleic, palmitic, linoleic, and palmitoleic acids, while stearic acid was present in low amounts. The Reed variety had the highest amount of oleic acid (61.18%) among all studied varieties (Nasri et al., 2021). A previous study (Bob Bergh, 1992) reported that linoleic acid was slightly above 21%, which agrees with the present findings of Hass avocado of 26.1-21.8%. Increasing polyunsaturated (PUFA) intake lowers LDL-C and decreases heart disease risk; increased PUFA intake lowers LDL-C by increasing LDL receptor activity (Teng et al., 2016; Weschenfelder et al., 2015).

Conclusion

This is one of the pioneer studies on the nutritional profile of Hass avocados in Kenya. The study revealed that the size of Kenyan avocados and the pulp, seed, and peel content vary slightly but within recommended global ranges. These variations could be due to environmental variables, crop management practices, altitude, weather conditions, and soil conditions. The nutritional value equally points to the need to consume more avocados to meet body requirements of some nutrients. Kenyan Hass avocados meet the required export quality in terms of size (calibre), pulp-to-seed and peel ratio was within acceptable limits, the nutritional composition of avocados and their lipid content is in line with those reported in key avocado-producing and exporting countries. The fatty acid profile of the avocados is consistent with high quality lipids with high unsaturated fatty acid content. Continued emphasis on quality improvement, sustainability, and market access will help Kenya strengthen its position in the global avocado trade.

The avocado from Kenya meets the minimum 58% oil; hence, it is suitable for extraction of avocado oil. The fatty acid profile makes Kenyan avocados nutritionally suitable regarding unsaturated fatty acid content. The overall quality of Kenyan avocados conforms to and is similar to that of top global origin destinations like Mexico.

Acknowledgement

The authors acknowledge KIRDI and JICA for supporting this research through funding sample analysis.

Conflict of interest

The authors declare no interest whatsoever in the funding and how the research was done.

Author Contribution

FOO: Designed, Coordinated the research, drafted and reviewed the manuscript
BO: writing and reviewing the manuscript
WM: writing and reviewing the manuscript
JKL: writing and reviewing the manuscript
GO: writing and reviewing the manuscript
JA: writing and reviewing the manuscript
WN: writing and reviewing the manuscript
CWM: writing and reviewing the manuscript

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