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Effects of Processing—Cooking and Drying—On Iron Content of Five Kenspot Sweetpotato Leave Varieties Grown in Bomet, Kenya

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Abstract

Sweetpotato production is the third-largest among root and tuber crops in Kenya, following Irish potato and cassava. Despite their nutritional richness—being high in vitamins, minerals, proteins, polyphenols, and beneficial micro-components—sweetpotato leaves are underutilized as a vegetable in many diets worldwide. This limits their potential to alleviate micronutrient deficiencies and enhance human health. This study aimed to evaluate the iron content of five Kenspot sweetpotato leaf varieties (Kenspot 1 - 5), developed by scientists at the Kenya Agricultural and Livestock Research Organization, and to assess how drying and cooking processes influence their iron levels. Freshly harvested leaves were collected from plots in Bomet County, arranged in a randomized complete block design, and analyzed for iron content directly as raw leaves. The remaining leaves were subjected to processing: drying and cooking, followed by iron analysis. The methodology adhered to the AOAC Official Method 2015.06, conducted at KALRO Njoro laboratories. Results indicated that fresh leaves contained between 9.2 and 13.0 mg/100g dry matter, with Kenspot 2 having the highest (13.0 mg/100g) and Kenspot 5 having the second highest (10.5 mg/100g). After cooking, iron content decreased to a range of 5.5 mg/100g (Kenspot 3) to 9.9 mg/100g (Kenspot 2), with iron retention rates from 57.1% to 81.3%. Dried and cooked leaves showed further reduction, with iron levels between 7.0 and 10.5 mg/100g and retention rates from 54.1% to 61.8%. Significant differences were observed in iron contents across all varieties and processing methods. Overall, cooking and drying significantly reduce iron concentrations in the leaves. Based on these findings, to maximize iron intake, it is recommended to consume Kenspot sweetpotato leaves as cooked fresh rather than in dried form. This approach would enhance their nutritional contribution and help utilize this underused leafy vegetable more effectively for improved micronutrient nutrition.

Keywords

Sweetpotato Leaves, Iron Content, Cooking, Drying, Kenspot Sweetpotato Varieties

1. Introduction

Sweetpotato production is ranked third among the root and tuber crops produced in Kenya after Irish potato and cassava [1]. The sweetpotato crop is more resistant to diseases, pests, and tolerant to diverse climatic conditions compared to many other food crops grown in the tropics [2]. Sweetpotato is a twofold crop with the utilization of both the leaves and tubers as food for both human and livestock. However, most of the breeding work done on the sweetpotato crop has focused on utilization of its roots and not the leaves. Consequently, five Kenspot sweetpotato varieties (Kenspot 1, Kenspot 2, Kenspot 3, Kenspot 4 and Kenspot 5) were bred by scientists at the Kenya Agricultural and Livestock Research Organization (KALRO) [3]. The Kenspot sweetpotato varieties were developed to enhance food and nutrition security and also serve as climate-resilient crop suitable for various agro-ecological zones. The breeding of the Kenspot sweetpotato varieties aimed to promote the utilization of their roots for human consumption, while the vines were largely discarded and or fed to livestock after harvest.

Sweetpotato leaves can be harvested year-round in large quantities, with their annual yields surpassing those of many other green leafy vegetables [4]. They are abundant in vitamins, minerals, proteins, polyphenols, and various micro-components that confer health benefits [2] [4]. Despite their superior agronomic and nutritional qualities, sweetpotato leaves remain underutilized as a dietary vegetable in many regions worldwide. However, they have the potential to play a significant role in combating malnutrition, especially micronutrient deficiencies, and supporting overall health. In some Asian countries, West African nations like Nigeria, Sierra Leone, and Uganda [5]-[7] are regularly included in diets. Conversely, in Kenya, the intake of sweetpotato leaves is notably low [8]. Limited literature is available regarding their consumption. Given their high nutritional value and iron content, increasing their intake among vulnerable communities could help mitigate iron deficiency. Promoting their intake could also provide an alternative to other seasonal green leafy vegetables, thereby enhancing dietary diversity and nutritional intake.

Sweetpotato leaves are known to contain relatively high amounts of iron, ranging from 15 to 44 mg/100g [9]-[12]. Iron deficiency anemia is a public health concern not only in Kenya, but across the globe, necessitating the need for long-term, affordable and reliable strategies to mitigate the problem. Research focused on assessing the iron content in the leaves of the five Kenspot sweetpotato varieties is essential, as existing literature lacks such studies. This gap highlights the need for this investigation, which could help evaluate the potential nutritional contribution of these vegetables to human health.

In addition to determining the iron content in the five Kenspot sweetpotato leaves, the iron levels can be further influenced by the preparation methods, including the cooking and drying processes, which contribute to loss of important nutrients, including iron [13]. Cooking sweetpotato leaves can affect the retention of iron in the leaves. When vegetables are cooked in water for a long time, some of the water-soluble iron can leach into the cooking water, reducing the iron content in the vegetables [14]. On the other hand, cooking can also enhance the bioavailability of iron in some vegetables [15]. Heat breaks down certain compounds, such as phytic acid and oxalates, that inhibit iron absorption, making it easier for the body to absorb the iron. Additionally, drying is among the ancient techniques of food preservation [16] [17] that causes the dehydration of vegetables to prevent food spoilage easy storage and availability during off seasons. Although drying vegetables has benefits, it also poses the risk of nutrient loss. Iron is lost in dried vegetables during the drying process, during chopping and blanching [18]. Further losses of iron are experienced when the dried vegetables are rehydrated and the soaking water is discarded. As a result of drying, the iron content in vegetables may be lowered compared to the fresh form. The objectives of this study therefore are to assess the iron content of the five fresh raw Kenspot sweetpotato leaf varieties and further investigate the effect of cooking and drying on iron retention.

2. Materials and Methods

2.1. Planting of the Kenspot Sweetpotato Varieties

Five Kenspot sweetpotatoes varieties (Kenspot 1, Kenspot 2, Kenspot 3, Kenspot 4 and Kenspot 5) were planted in experimental plots at Agricultural Training Centre (ATC) Bomet farm in Bomet County in September 2021. The area has bimodal rainfall pattern that peak in April and November. The five sweetpotato varieties were laid out in a RCBD with three replications. The trial was planted in a field of 26 m × 15 m. A plot consisted of the 5 sweetpotato varieties with 5 rows each being 4 meters long with inter-row spacing of 1 meter and interplant spacing of 30cm. A larger plot was planted to allow random harvesting of the leaves hence minimize bias. To separate the varieties, a gap of 1.5 meters was left between the blocks. Three middle rows of the sweetpotato leaves samples of all the five varieties were then harvested in December 2021 on maturity at 12 weeks and transported to KALRO Njoro for iron content analysis. The experimental plot layout is shown in **Figure 1**.

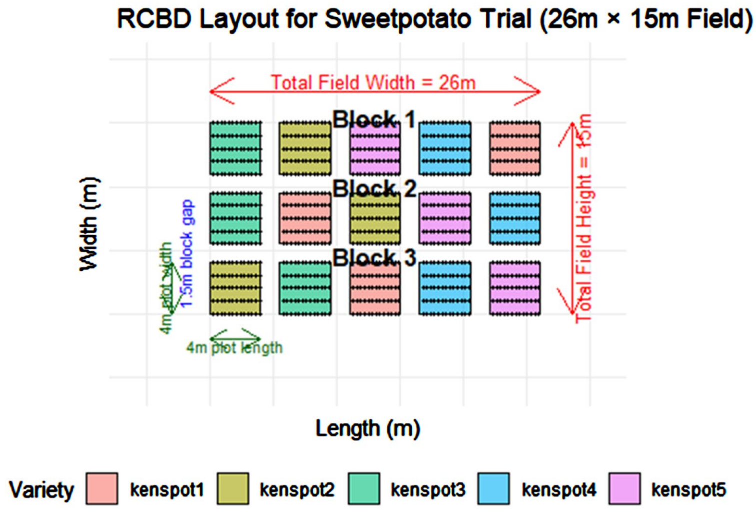

Figure 1. Experimental plot layout.

2.2. Harvesting and Cleaning of the Kenspot Sweetpotato Leaves Varieties

Five kilograms of the sweetpotato leaves of each of the five Kenspot varieties were harvested from the middle three rows to minimize border effect and likelihood of contamination from neighbouring plots. Care was taken to avoid contamination from the soil by following the following procedures; 1) sweetpotato leaves located within 30 cm from the apical tip were pinched from the plant with hands dressed in gloves, without using any tool. 2) The samples were packaged in perforated brown paper carrier bags and transported the same day to KALRO Njoro laboratory. Upon arrival at KALRO Njoro laboratory, all the harvested sweetpotato leaves samples were thoroughly washed in a 1% mild detergent solution (dish washing detergent) made with distilled water [19]. The washed sweetpotato leaves were then rinsed five times with distilled water, shaken to remove excess water before being stored in sealed polyethene bags in a refrigerator at 4˚C overnight and analyzed the following day in three replicates.

2.3. Preparation of Kenspot Sweetpotato Leaves Varieties for Iron Content Analysis

Fresh raw sweetpotato leaves: Five grams each of the raw fresh samples were removed from the refrigerator and placed in petri dishes for oven drying and analysis for iron content. The samples were analyzed in three replicates at KALRO Njoro laboratory where the fresh raw sweetpotato leave of the five Kenspot Varieties were all dried separately in a hot air oven (model 58H25OS) at 60˚C for about 72 hours, then cooled to ambient temperature. The samples were then milled separately using a laboratory hammer mill (coated with Teflon) (LM3100 model) and sieved through a mesh of 1 mm diameter. The samples were then analyzed in three replicated following the procedure given by the Association of Official Agricultural Chemists (AOAC) Official Method 2015.06 as described in AOAC collaborative study manual [20] as follows; for each of the five oven dried and finely ground Kenspot sweetpotato leaf samples, 0.3 g were weighed and placed in a dry, clean digestion tube. A digestion mixture (4 ml of selenium-sulphuric acid mixture, which is a catalyst) was added and allowed to react at room temperature for at least 2 hours. The digestion tubes were then heated to 200˚C in a block digester, allowed to cool and 3 successive portions of 1 ml of hydrogen peroxide (H_2O_2) added, waiting for at least 10 seconds between additions. The tubes were returned to the block digester and temperatures were adjusted to 330˚C. The digestion was complete when the samples became colourless or light yellow. The tubes were then removed from the block digester and cooled to room temperature and then the contents were transferred into a 50 ml volumetric flask and made up to the mark with deionized water. The digested samples were analyzed for iron using the Atomic Absorption Spectrophotometer (AAS), Shimadzu Model AA-6300, Kyoto-Japan [21]. Calibrated standard serial dilution of iron ranging in concentration of 1.25 ppm, 2.5 ppm, 5 ppm, 7.5 ppm and 10 ppm was used to draw a calibration curve. Iron was measured by atomic absorption at a wavelength of 248.3 nm. The absorbencies obtained were used to estimate the concentrations of the metal ions from the curve in the different samples.

Cooking of fresh raw sweetpotato leaves: About a half kilogram each of the cleaned fresh raw sweetpotato leaves were removed from the refrigerator and steamed in a stainless steel steaming rack for seven minutes while continuously turning the sweetpotato leaves. The cooked vegetables were left to cool to room temperature. Five grams of steamed sweetpotato leaves from each of the five Kenspot varieties were individually placed in petri dishes and dried in a hot air oven (model 58H25OS) at 60˚C for approximately 72 hours, then cooled to room temperature. The samples were then ground separately using a Teflon-coated laboratory hammer mill (LM3100 model) and sieved through a 1 mm mesh. The iron content of the cooked samples was analyzed following the procedure outlined in the AOAC Official Method 2015.06, as described in the AOAC manual [20].

Drying of sweetpotato leaves: About one kilogram each of the cleaned five sweetpotato leaves varieties was removed from the refrigerator. They were then blanched in boiling water at a temperature of 100˚C for three minutes to inactivate enzymes, preserve colour and flavour [22]. The leaves were then cooled immediately by immersing them in cold distilled water for 30 seconds and then strained to remove excess water. The leaves were then spread evenly in single layers on drying trays and sun-dried on raised surfaces until the moisture content of 6% was attained. The dried sweetpotato leaves were then packed and sealed in airtight plastic containers to prevent moisture absorption and stored at room temperatures for analysis of iron in three replicates following the procedure described in AOAC manual [20].

Cooking of the dried sweetpotato leaves: The dried sweetpotato leaves, stored in an airtight container at ambient temperature, were rehydrated by soaking in water at a ratio of 1:3 (weight of leaves to volume of water) for 15 minutes. Excess water was drained and the samples were steamed in a stainless steel steaming rack for 7 minutes, with continuous turning to ensure even cooking. The samples were left to room temperature and analyzed for iron content in three replicates following the procedure given by the Association of Official Agricultural Chemists (AOAC) Official Method 2015.06 as described in AOAC manual [20].

2.4. Data Analysis

Data were analyzed and presented as means ± standard deviations. The normality of the data within each group was assessed using the Shapiro-Wilk test. Most groups conformed to normality assumptions ($p > 0.05$), except for the iron content of fresh raw sweetpotato leaves, which underwent a natural logarithm transformation to meet normality criteria. Homogeneity of variances across groups was confirmed by Levene's test ($p > 0.05$). Subsequently, a one-way ANOVA was performed to evaluate differences in iron content across the various varieties and preparation methods. Where significant effects were found, the Bonferroni post-hoc test was used to separate means.

3. Results

3.1. Iron Content of Fresh Raw Kenspot Sweetpotato Leaves Varieties

The iron content of the five Kenspot sweetpotato fresh raw leaves ranged from 9.0 ± 0.32 mg/100g to 13.0 ± 0.14 (Table 1). The iron content was highest in Kenspot 2 (13.0 ± 0.14 mg/100g) followed by Kenspot 5 sweetpotato variety, which had an iron content of 10.5 ± 0.28 mg/100g. The leaves of Kenspot 1 sweetpotato variety ranked third in iron concentration with an iron content of 9.8 ± 0.27 mg/100g, Kenspot 4 sweetpotato variety leaves had the second lowest iron content of 9.2 ± 0.35 mg/100g, while Kenspot 3 had the lowest iron content (9.0 ± 0.32 mg/100g) among the five Kenspot varieties. The ANOVA analysis showed a statistically significant difference in the means of the iron content of the five Kenspot sweetpotato leaf varieties ($p = 0.000$), which led to further analysis of the data to separate

Table 1. Average iron content of fresh and raw, dried, cooked fresh, and cooked dried leaves of five Kenspot sweetpotato varieties (mg/100g dry matter).

Treatment	Iron content of five Kenspot sweetpotato leaf varieties					p-value
	1	2	3	4	5	
Fresh raw leaves	$9.8^{c} \pm 0.27$	$13.0^{a} \pm 0.14$	$9.0^{c} \pm 0.32$	$9.2^{c} \pm 0.35$	$10.5^{b} \pm 0.28$	0.000
Fresh cooked leaves	$5.6^{c} \pm 0.35$	$9.0^{a} \pm 0.12$	$5.5^{c} \pm 0.26$	$7.3^{b} \pm 0.66$	$8.5^{ab} \pm 0.21$	0.000
Dried leaves	$8.7^{c} \pm 0.74$	$10.5^{a} \pm 0.52$	$7.0^{c} \pm 0.56$	$8.1^{c} \pm 0.75$	$9.4^{b} \pm 0.12$	0.000
Dried cooked leaves	$5.5^{c} \pm 0.61$	$7.9^{a} \pm 0.06$	$4.9^{c} \pm 0.45$	$5.7^{bc} \pm 0.52$	$6.5^{b} \pm 0.43$	0.000

Values with different superscripts in the same row are significantly different ($p < 0.05$). Measurements = mg/100g ± Standard Deviation.

the means using the Bonferroni test. The results revealed a significant statistical difference in the average iron content between Kenspot 2 and Kenspot 5. Additionally, there was a notable statistical difference in the average iron content of the leaves between Kenspot 5 and each of the Kenspots 1, 3, and 4 with no significant statistical difference found in the mean iron content among Kenspots 1, 3, and 4.

The iron content in various sweetpotato leaf preparations across five different varieties is shown in Figure 2. Generally, fresh raw and dried cooked leaves have higher iron content compared to cooked fresh or cooked dried leaves with each variety follows this trend.

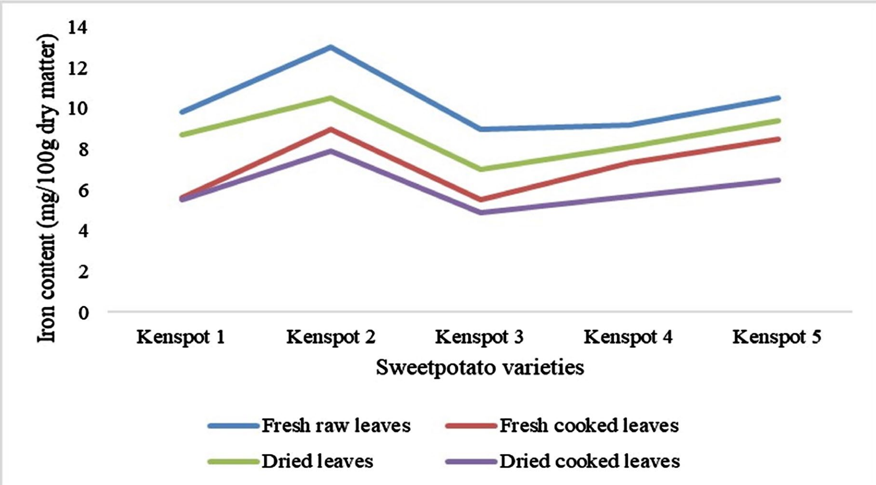

Figure 2. Iron content in various sweetpotato leaf preparations across five different varieties.

3.2. Iron Content of Fresh Cooked Kenspot Sweetpotato Leaves Varieties

The study also determined the iron content of the five Kenspot sweetpotato leaf varieties when cooked fresh and results tabulated in Table 1. The fresh cooked sweetpotato leaves had iron content ranging from 5.5 ± 0.26 mg/100g to 9.0 ± 0.12 mg/100g. Similar to the fresh raw leaves, the iron content was ranked in descending order as follows: Kenspot 2 had the highest iron content, followed by 5, 4, and 1, with Kenspot 3 exhibiting the lowest iron content. There were no statistical differences between Kenspots 2 and 5, Kenspots 5 and 4, and Kenspots 1 and 3; however, significant statistical differences were found between Kenspots 2 and 4, Kenspots 2 and 1, Kenspots 2 and 3, as well as between Kenspots 5 and 1 and Kenspots 5 and 3.

3.3. Iron Content of Dried Kenspot Sweetpotato Leaves Varieties

The analysis of dried sweetpotato leaves demonstrated varying levels of iron content across different Kenspots varieties (Table 1). Kenspot 2 exhibited the highest iron content, recorded at 10.5 ± 0.52 mg/100g, followed by Kenspot 5 with 9.4 ± 0.12 mg/100g. Kenspot 4 showed a moderate iron content of 8.7 ± 0.74 mg/100g, while Kenspot 1 had a lower value of 8.7 mg/g. The lowest iron content was observed in Kenspot 3, with a measurement of 7.0 ± 0.56 mg/g. Analysis of variance indicated a significant difference in iron content among the Kenspots, with a p-value of 0.000. Due to the statistically significant difference, Bonferroni test was used to separate the means. The results indicted statistical significant difference between Kenspots 2 and 4, 2 and 1, and 2 and 3. However, there was no statistically significant difference between Kenspots 2 and 5, and also Kenspots 1, 3 and 4.

3.4. Iron Content of Dried Cooked Leaves of the Five Kenspot Sweetpotato Varieties

The analysis of dried cooked leaves revealed noteworthy differences in iron content across the various Kenspots (Table 1). The ANOVA test showed that Kenspot 2 had the highest iron content, showing an average of 7.9 ± 0.06 mg/100g. In comparison, Kenspot 5 had a moderate iron level of 6.5 mg/100g, while Kenspot 4 demonstrated a similar content of 5.7 ± 0.52 mg/100g. Kenspot 1 recorded an average iron content of 5.5 ± 0.61 mg/100g, and Kenspot 3 exhibited the lowest at 4.9 ± 0.45 mg/g. Statistical analysis revealed a significant difference in iron content among the Kenspots varieties, with a p-value of 0.000. When means were separated using Bonfenorri statistical test, Kenspots 1, 3, and 4 displayed no statistical difference, whereas Kenspots 2 and 5 showed significant difference, reflecting their higher iron content than the earlier mentioned sweetpotato leaves.

3.5. Iron Retention of the Five Kenspot Sweetpotato Leaves Varieties after Drying and Cooking

The percentage retention of iron content was analyzed and summarized in Table 2. The iron content of the fresh raw leaves served as the baseline, with all fresh raw sweetpotato leaves from all the five sweetpotato varieties reported to have 100% iron retention.

Table 2. Percentage (%) iron retention of five Kenspot sweetpotato leaves varieties when fresh and raw, dried, cooked fresh and cooked dried.

Treatment	Percentage iron retention of the five Kenspot varieties				
	1	2	3	4	5
Fresh raw leaves	100.0	100.0	100.0	100.0	100.0
Fresh cooked leaves	57.1	69.3	60.9	79.3	81.3
Dried leaves	88.8	81.0	77.5	88.0	89.7
Dried cooked leaves	56.1	57.8	54.3	62.0	61.8

In contrast, the dried sweetpotato leaves exhibited the highest retention of iron, ranging from 89.7% for Kenspot 5 to 77.5% for Kenspot 3. However, the dried cooked sweetpotato leaves demonstrated the lowest iron retention, with percentages of 54.3% for Kenspot 3 and 62.0% for Kenspot 4. Notably, Kenspot 3 consistently showed lower iron retention across all processing methods (fresh cooking, drying, and cooking dried), while Kenspots 5 and 4 appeared to preserve more nutrients during processing.

As depicted in **Figure 3**, the highest percentage retention of iron content was observed in dried leaves, followed by fresh cooked leaves, with dried cooked leaves exhibiting the lowest retention. This trend applied to the leaves of all the five Kenspot sweetpotato varieties.

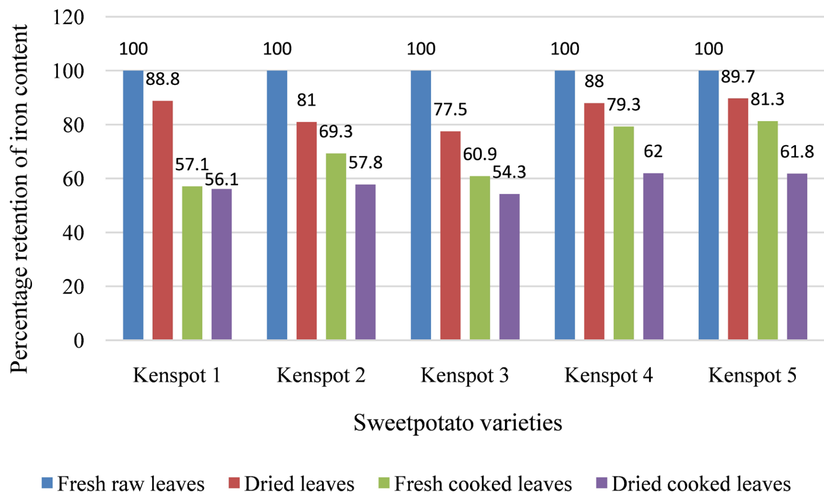

Figure 3. Percentage retention of iron content following various preparation methods, presented in descending order.

4. Discussion

This study aimed to investigate the iron content of five Kenspot sweetpotato leaves varieties when fresh, dried and cooked. The findings highlight remarkable iron content in the fresh sweetpotato leaves ranging from 9.2 and 13.0 mg/100g across the different varieties. The variation among sweetpotato leaf varieties is mainly caused by genetic differences that influence how plants uptake, transport, and store nutrients [23]. Other studies conducted to determine the iron content of sweetpotato leaves have shown almost similar results. An earlier study conducted in Tanzania found that iron content of the leaves of two varieties of sweetpotato (GMSPL and PMSPL varieties) to be 15.22 and 17.48 mg/100g, respectively [11], which was slightly higher than that found in the Kenspot sweetpotato leaves varieties in this study. It is evident that different varieties of sweetpotato leaves yield different iron contents. Others research findings have shown higher iron contents in the different varieties of fresh raw sweetpotato leaves than the finding of this study. A study conducted to determine the iron content of green and purple sweetpotato leaves revealed amounts of 24.0 and 23.9 mg/100g for green and purple sweetpotato leaves, respectively [24]. Another study in Bangladesh, which investigated iron content in nine sweetpotato varieties showed a range of iron in their leaves to be between 19.89 and 44.39 mg/100g dry matter [12]. The causes of variation could include geographical location, agricultural practices, and genetic makeup of the varieties. Other vegetables, such as amaranth, have been shown to have as high as 53.53 mg/100g dry weight of iron [25]. However, these vegetables thrive only in wet seasons. Other commonly consumed exotic vegetables in Kenya, such as kale and cabbage have diverse iron contents. Various varieties of kale have been reported to have diverse iron content. Mature leaves of *Brassica oleracia* (Red Russian kale) were found to have 2.39 mg/100g dry weight. The other two kale varieties *Brassica oleracea* var. *acephala* (Scarlet and Dwarf Blue curled) had iron contents of 2.69 mg/100g and 2.39 mg/100g respectively [26]. Cabbage is known to have a lower iron content than kale of about 2.15 mg/100g dry weight [27]. As much as spinach has a higher iron content than kale (*Sukumawiki*) and cabbage, it is also known to have a high oxalate content, which is an anti-nutritive factor [28]. Oxalate precipitates with iron, forming insoluble compounds and making iron unavailable for absorption in the human body.

Kenspot sweetpotato leaves iron content is within the range of indigenous vegetables that are consumed in the region. Analysis of iron content for *Cleome gynandra* (spider plant), a common indigenous vegetable in Kenya is 10.17 mg/100g dry weight during the wet season and higher (23.93 mg/100g dry weight) during the dry season [29]. Surprisingly, other studies give the iron content of spider plants to be lower than that of cabbage. Another study reported the iron content of spider plant to be 0.38 mg/100g dry weight [30] while Ouédraogo *et al.* [31] presented 1.90 mg/100g dry weight. Other commonly consumed vegetables, such as cowpea leaves have been shown to have 33.28 mg/100g (Icirikukwai variety of Uganda), 37.94 mg/100g (Elbelat variety of Uganda), 34.91 mg/100g (Dawaka variety of Tanzania) [32]. Vine spinach was found to have 29.09 mg/100g iron content [33], a figure higher than that of sweetpotato leaves. Unlike sweetpotato, most green leafy vegetables are available only during rainy seasons and scarce during the dry seasons. Furthermore, the texture of cowpea leaves and spinach is also not palatable to part of the population due to the fibery effect of cowpea leaves and the slimy texture of the vine spinach, hence reducing the number of those consuming the vegetable. On the other hand, sweetpotato is a hardy crop that is drought tolerant, resistant to pests and diseases, and can be grown in many agro-ecological zones. It has also been found to be palatable to many individuals and its leaves are available throughout the year. In this case, sweetpotato leaves can be used as readily available sources of iron for women of reproductive age and other groups.

This study further analyzed the effect of cooking and drying sweetpotato leaves on iron content. Raw fresh sweetpotato leaves contain between 9.2 and 13 mg/100g iron dry weight. When these leaves were dried but not cooked, the iron level drops to between 8.1 and 10.5 mg/100g, depending on the variety. With cooking, iron content measured between 5.5 and 9.0 mg/100g for fresh leaves and 4.9 and 7.9 mg/100g for dried leaves after both were cooked. The findings of the study reveal a trend that iron content declines with both drying and cooking, whether separate or combined. Raw fresh leaves contain the highest amount of iron, with sequential losses at each processing step. Drying is an effective, affordable solution to ensure vegetable availability across all seasons, but leads to iron loss [34]. Iron loss experienced during the drying of sweetpotato leaves in this study aligns with previous research. Significant iron loss was observed when the PMSPL sweetpotato variety grown in Uganda was sun-dried [11]. Similar findings have been reported in studies involving other vegetables. Chege *et al.* [22] found that solar drying of amaranth leaves decreased their iron concentration from 8.48 ± 0.05 mg/100g to 7.89 ± 0.02 mg/100g, reflecting a 5.3% reduction, with no significant differences noted. Reference [34] studied the impact of drying on the iron content of stinging nettle leaves (*Urtica dioica*) and found negligible increases in iron content after drying. For spinach (*Spinacia oleracea* L.), fresh leaves contained 7.5 mg/100g, which increased slightly to 8.3 mg/100g when oven-dried. In contrast, Oboh and Madojemu [35] reported that blanching and drying of *Talinum triangulare* leaves (commonly known as waterleaf) resulted in lower iron retention of 63.04% with significant differences noted ($p > 0.05$). Their findings indicated no statistically significant difference ($p < 0.05$) between blanched and unblanched leaves before drying.

Iron, as a mineral, is usually stable and is not lost during normal drying temperatures [36]. However, other factors such as high temperature, relative humidity, air velocity and initial moisture content may affect and cause iron loss [37]. Kakade and Neeha [37] state that the ideal temperature ranges for drying fruits and vegetables are between 55˚C to 75˚C. In our study, this range was relevant since the vegetables were dried in the sun, with tropical sun drying temperatures typically ranging from approximately 25˚C to 35˚C [38] [39]. Many treatments used before drying affect the chemical changes that transpire in the course of drying. Factors such as drying duration, atmospheric temperature and ambient humidity influence the final quality of dried vegetables [37].

Cooking of the leaves prompted further reductions in iron content. When raw leaves were cooked, the iron falls from between 13 and 9.2 mg/100g, to between 7.0 and 10.5 mg/100g dry weight and further to between 4.9 and 7.9 mg/100g when dried leaves were cooked. This decline can be attributed to several widely recognized factors. During boiling, iron may leach into the cooking water [40]. Part of the iron may also bind to insoluble fibers such as lignin, cellulose and hemicellulose forming complexes [41]. Other research indicates similar decreases in iron content when green leafy vegetables are cooked. A study on cooking of amaranth leaves showed decrease of iron content from 16.2 to 8.5 mg/100g, and cowpea leaves from 3.9 to 3.0 mg/100g [42]. A study conducted in Zimbabwe found that steaming sweetpotato leaves resulted in significant iron loss: after ten minutes, green and purple leaves lost 39.17% and 31.34% of their iron, respectively, with retention further decreasing to approximately 57.9% after 15 minutes [24]. Another study indicated that boiling vegetables generally leads to a reduction in iron levels. For instance, carrots and peas experienced iron content losses of approximately 19% and 5.8%, respectively [15]. Conversely, some vegetables such as pumpkin leaves, spinach, sathkora, and green pepper showed an increase in iron content by 11.6%, 5.8%, 6.5%, and 9.7%, respectively [15]. This increase may result from iron binding to other food components, such as oxalates, which inhibits its extraction into the cooking liquid [43]. Another investigation also highlighted the reduction of iron content when vegetables are boiled. For example, *Rumex pulcher* L. (fiddle dock), *Asparagus acutifolius* L. (wild asparagus), *Bryonia dioica* L. (drake), *Humulus lupulus* L. (common hops), and Tamus communis L. (black bindweed) demonstrated iron loss percentages of 9.1%, 38.9%, 51.2%, 1.7%, and 10.4%, respectively [43]. The decline in iron levels may be attributed to leaching into the cooking liquid or the presence of anti-nutritional factors, such as oxalic acid, which reduce nutrient availability for absorption [15].

The present study identifies sweetpotato leaves as an excellent source of iron. It was observed that cooking fresh vegetables results in high iron retention, whereas drying and subsequent cooking lead to further iron loss. These findings emphasize the potential of sweetpotato leaves as a valuable yet underutilized iron source in diets. Even with processing-induced losses, their iron content remains comparable to many traditional leafy greens. Given the significance of sweetpotato leaves, there is a crucial need for public awareness through the health sector to promote their use, especially in communities susceptible to iron deficiency where the plant is prevalent but the leaves are underused. Incorporating these leaves into local diets can help address micronutrient deficiencies in a cost-effective manner. The study stresses the importance of food preparation methods in preserving iron content. Since both drying and cooking lead to significant iron loss, dietary recommendations might encourage drying methods such as solar or oven drying at lower temperatures, or the adoption of quick-drying techniques to retain more iron. Other preparation methods, such as gentle cooking practices such for example steaming rather than boiling to minimize leaching, using less water, or retaining cooking liquid in the vegetable could minimize iron loss.

Given that women of reproductive age and young children are at highest risk for iron deficiency, interventions can target these groups specifically. Incorporating sweetpotato leaves into foods commonly eaten by women and children, or into fortified products, can boost iron intake where animal-source foods (with more absorbable iron) are less available or affordable. Plant-based iron is less well absorbed due to the presence of inhibitors (phytates, oxalates), some of which are reduced with cooking. Dietary guidance should encourage consuming iron-rich sweetpotato leaves with vitamin C-rich foods (like tomatoes, citrus, or bell pepper), which can increase iron bioavailability. This can be easily woven into recipes and nutrition messaging.

Policy makers, governments and NGOs can incorporate the production and consumption of sweetpotato leaves into nutrition-sensitive agriculture projects, and food security initiatives. Additionally, they can include sweetpotato leaves in food-based dietary guidelines and support the development of value chains—covering production, distribution, and post-harvest processing and value addition—for sweetpotato leaf products.

5. Conclusion

Kenspot varieties of sweetpotato leaves have relatively high iron content. Sweetpotato leaves are drought tolerant and thrive well with minimal water, have a high yield of leaves, are highly palatable, easy to cultivate and pest and disease-resistant. Drying and cooking of the sweetpotato leaves caused a loss of iron. Sweetpotato leaves as a vegetable can mitigate iron deficiency among vulnerable groups, especially in areas with low rainfall.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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