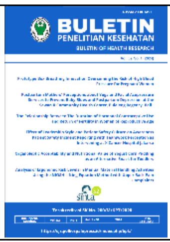

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Analysis of Mineral and Vitamin Content in Sweet Potato Leaves and Their Potential Role in Hemoglobin Formation

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ABSTRACT

Background: Sweet potato leaves are widely consumed in Indonesia and have been traditionally used to help overcome anemia due to their mineral and vitamin content. This study aimed to analyze the mineral and vitamin C content of green and red sweet potato leaves and to assess their potential role in supporting hemoglobin formation.
Methods: This type of research is descriptive by explaining the results of laboratory tests on water extracts and red and green sweet potato leaves. Samples of water extract from 10 red sweet potato leaves and 10 green sweet potato leaves. Meanwhile, for the leaf extract, each leaf was air-dried for 1 week and then placed in an oven at 105^{0}C for 3 days until the weight remained constant. To analyze the minerals, samples were tested using a SHIMADZU Type AA-7800 Atomic Absorption Spectrophotometer (AAS). Vitamin C analysis was performed using the titration method.
Results: The results of the study were obtained from the green leaf extract Fe 56.36 gr, Ca 1052.2 gr, Mg 3.3 gr. Red leaves Fe 55.46 gr, Ca 285.9 gr, and Mg 32.46 gr. The content of boiled water extract for 10 minutes Fe 0.15 mg/l, Ca 0.54 mg/l, Mg 1.9 mg/l. Pink leaves Fe 0.08 mg/l, Ca 0.745 mg/l, Mg 1.88 mg/l. Dark red leaves Fe 0.11 mg/l, Ca 0.95 mg/l, Mg 1.92 mg/l. Water extract with added sugar on green leaves Fe 0.04 mg/l, Ca 0.84 mg/l, and Mg 1.89 mg/l. Red leaves Fe 0.08 mg/l, Ca 1.27 mg/l, and Mg 1.91 mg/l. The vitamin C content of green sweet potato leaves is higher than that of red sweet potato leaves, indicating its potential as a more effective food source to increase hemoglobin levels and overcome anemia.
Conclusion: Sweet potato leaves contain important nutrients, based on the results of extracts from green sweet potato leaves containing higher concentrations of minerals and vitamin C.

INTRODUCTION

The exploration of natural resources for medicinal and nutritional purposes has gained considerable momentum in recent years, particularly in the biodiversity-rich region of West Papua. Sweet potato leaves are an alternative to treat anemia and increase hemoglobin levels, as shown by increasing scientific evidence. Studies conducted on rats have demonstrated the efficacy of sweet potato leaf extract in improving anemia underlining its potential as a therapeutic agent (Dewi Kartika Sari & Putri Wahyu Wigati, 2021). Hemoglobin levels in pregnant women are categorized as normal if they exceed 11 gr/dl, mild if between 8-11 gr/dl, and severe if below 7 gr/dl, which highlights the varying degrees of this condition and the need for accurate assessment (Kuma et al., 2021).

Furthermore, a review of the existing literature has revealed a positive correlation between consumption of sweet potato including its leaves and increased hemoglobin levels in pregnant women, indicating beneficial effects on maternal health. Additional studies have shown that boiled sweet potato leaves, can contribute to increased hemoglobin levels in pregnant women highlighting an easily accessible and cost-effective intervention strategy. Purple sweet potato has also been proposed as a viable food alternative to increase hemoglobin levels and prevent anemia during pregnancy, offering a natural and tasty option for pregnant women (Farhan & Dhanny, 2021). In addition, administration of boiled sweet potato leaf extract for one week has been shown to be effective in increasing hemoglobin levels in adolescent girls, demonstrating its potential in overcoming iron deficiency in vulnerable populations (Dewi Kartika Sari & Putri Wahyu Wigati, 2021 ; Nuryanti et al., 2022).

The maternal mortality rate in Indonesia is still high, at 305 per 100,000 live births in 2022. Underlines the urgency to address maternal health issues with a national target to reduce it to 183 per 100,000 live births by 2024. The situation in West Papua is particularly concerning with a maternal mortality rate of 343 per 100,000 live births, far exceeding the target. From the sustainable development goal of less than 70 per 100,000 live births, which shows disparities in access and health care outcomes across the archipelago. The Sustainable Development Goals emphasize the importance of improving maternal and child health, with Goal 3 specifically focusing on ensuring healthy lives and promoting well-being for all at all ages (Yekti, 2020; kemenkes RI, 2022; BPS Papua Barat, 2020).

The Indonesian government's strategy to combat anemia includes the provision of iron supplements through iron tablets, an important intervention aimed at increasing hemoglobin levels and preventing complications. In 2021, the coverage of providing at least 90 iron tablets in Indonesia reached 84.2% (Ministry of Health of the Republic of Indonesia, 2020). This is an increase compared to 83.6% in 2020, highlighting efforts to improve compliance with the iron supplementation program. Bali showed the highest coverage at 92.6% while West Papua lagged behind with only 37.5%, indicating gaps in program implementation and access to health services across provinces. However, West Papua has shown improvement since 2019, when its coverage was only 11.2%, indicating progress in addressing anemia in the region. Non-pharmacological approaches such as consuming boiled sweet potato leaf water, offer an alternative strategy to manage anemia in pregnant women.

Sweet potatoes are not only a staple food in West Papua but are also an important agricultural product in areas such as West Java, Central Java, East Java, and North Sumatra. This highlights the wide availability and consumption of sweet potatoes throughout Indonesia. The unique nutritional composition of sweet potatoes distinguishes them from other cultivated and consumed foods, making them a valuable resource in addressing malnutrition (Sibuea, 2013). Sweet potatoes are a food ingredient that is different from other types of food cultivated and consumed by the Manokwari community, because sweet potatoes contain a variety of nutrients. So besides being used as rice, the Manokwari community uses sweet potatoes as a local food for daily consumption (Dwita Iriani Nainggolan et al., 2022). In addition to being consumed themselves, the results of the sweet potato garden are also sold in the market along with their leaves. So sweet potato leaves are easy to find in Manokwari.

The focus of the study on Manokwari Regency is very important, because this region has a unique agro-ecological environment that can affect the phytochemical profile of sweet potato leaves. By examining sweet potato leaves cultivated in geographical locations, this study can provide valuable insights into potential variations in chemical composition and their impact on hemoglobin levels (Tombokan et al., 2021). Identification of these key compounds will not only contribute to a better understanding of the health benefits associated with sweet potato leaves.

Understanding these mechanisms is essential to optimize the use of sweet potato leaves as a natural treatment for anemia and ensure its safe and effective application. In, this study seeks to provide a comprehensive scientific basis for the traditional use of sweet potato leaves in treating anemia and improving health, while contributing to the development of evidence to increase hemoglobin levels in the population.

METHODS

This study used a descriptive research design, which carefully characterized laboratory findings related to the elemental and vitamin composition of sweet potato leaves (Dharma, 2011). The study was conducted in the analytical chemistry laboratory at the Faculty of Mathematics and Natural Sciences, University of Papua, which took place from May 7 to June 5, 2024. It was complemented by analyses conducted in the Agricultural Product Technology laboratory at the same university between June 14 and June 19, 2024. This study has obtained a research ethics eligibility letter from the Ethics Commission of the Health Polytechnic of the Ministry of Health of Sorong on April 26, 2024 with the number DM.03.05/004/084/2024.

The sample set consisted of green and red sweet potato leaves and their respective water extracts, with each category represented by ten individual leaves. Data acquisition focused on quantifying the concentrations of iron, calcium, magnesium, and vitamin C present in both varieties of sweet potato leaves. To prepare leaf samples, ten leaves from each variety of sweet potato were carefully washed and air-dried for a week, followed by oven drying at 105°C for three days until they reached a consistent weight.

The dried leaves were then ground into a fine powder to ensure homogeneity, an essential step for accurate elemental analysis. Next, the powdered sample was ashed, and the resulting ash was treated with 20 ml of aqua regia (a 1:1 mixture of hydrochloric and nitric acids), a powerful oxidizing agent known for its ability to dissolve noble metals and facilitate the release of bound minerals, consisting of a 1:1 mixture of hydrochloric and nitric acids. This mixture was then heated to boiling for 10 minutes under a watch glass cover to prevent loss of volatile components, ensuring complete digestion of the sample matrix. After digestion, the sample was cooled to room temperature to prevent adverse reactions during subsequent filtration. The cooled digestate was filtered through filter paper to remove undissolved particles, ensuring a clear solution for analysis. The filtrate was then transferred to a 50 ml volumetric flask and diluted to the mark with pure water to achieve the desired concentration for instrumental analysis.

For the preparation of aqueous extract, ten washed sweet potato leaves were soaked in 100 cc of water in a pot and boiled gently for 10 minutes to extract the water-soluble components. The boiling process was carefully controlled to concentrate the extract to about 50 cc, increasing the concentration of the target analytes. After boiling and concentrating, the aqueous extract was poured into a glass container to separate it from the remaining solids. In cases where a sweetened extract was desired, sugar was added to the aqueous extract while it was still hot, facilitating dissolution and ensuring a homogeneous mixture. The mineral content especially calcium, magnesium and iron in the prepared samples was determined using a SHIMADZU AA-7800 Atomic Absorption Spectrophotometer, a highly sensitive technique for measuring trace elements in complex matrices. Determination of carbohydrate content by the iodometric titration method, namely 1 gram of sample was placed in a 500 ml Erlenmeyer flask, added 25 ml of 1.25% H_2SO_4, then boiled for 3 hours using an upright cooler. Cool and neutralize with 3.25% NaOH using red litmus and transfer into a 100 ml measuring flask and squeeze with distilled water to the line mark then filter (Nurilmala & Mardiana, 2019).

After that, 10 ml was pipetted and put into an Erlenmeyer flask, 5 ml of 25% HCL was added, left for 12 hours, then neutralized with 2.5 N NaOH using phenolphthalein indicator. Distilled water was added until the volume was 50 ml and 5 ml of Luff Schoorl reagent was added and heated using an electric heater while shaking for 3 minutes. Cool immediately and add 10 ml of 10% KI and 15 ml of 25% H_2SO_4, homogenize, then titrate with 0.1 N $Na_2S_2O_3$ using starch indicator (Skenderidis et al., 2018). Vitamin C content is determined using the titration method, which is a classic analysis technique that relies on the stoichiometric reaction between vitamin C and titrant. Comprehensive analysis of sweet potato leaves as shown in Figure 1.

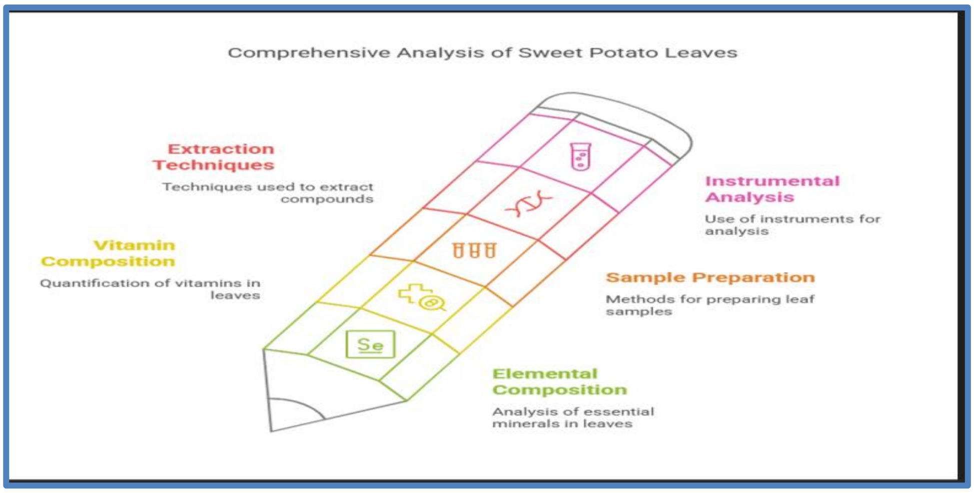

Figure 1. Comprehensive Analysis of Sweet Potato Leaves

RESULTS

Mineral Content

This research was conducted at the Chemistry Laboratory, Faculty of Mathematics and Natural Sciences, University of Papua. Research was conducted to see the mineral content in green and red sweet potato leaves. The mineral content tested includes Iron (Fe), Calcium (Ca) and Magnesium (Mg). The research samples were made from green and red sweet potato leaves. in the form of water and extract.

a. Mineral Content in Sweet Potato Leaf Water Extract

The mineral composition of aqueous extracts derived from sweet potato leaves, particularly green and red varieties, was carefully analyzed to ascertain the impact of boiling time and sugar addition on mineral concentrations. The extraction process involved soaking ten thoroughly cleaned sweet potato leaves in 100 cc of water in a pot, followed by boiling over low heat for 10 minutes (Awol, 2014; Tang et al., 2020). Heating was stopped when the water evaporated to about 50 cc, and the resulting aqueous extract was then poured into a glass container (Awol, 2014). For samples requiring the addition of sugar, mixing was carried out while the aqueous extract was still hot, ensuring complete dissolution and uniform distribution in the matrix (Awol, 2014).

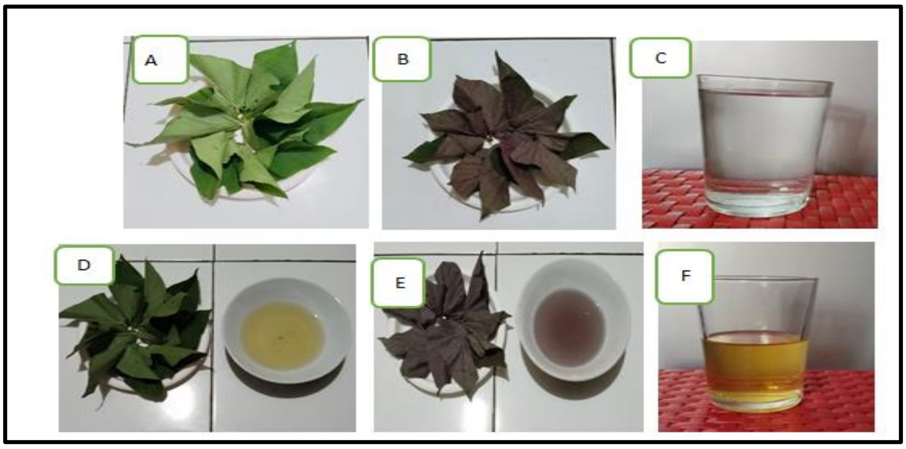

Figure 2: A. 10 green sweet potato leaves, B. 10 red sweet potato leaves, C. Water 100 cc. D. The result of boiling green leaves. E. The result of boiling red leaves. F. Preparation in glass

Analysis of aqueous extracts from sweet potato leaves revealed significant variations in mineral concentrations based on leaf color and boiling time (Awol, 2014). Specifically, green leaves boiled for 10 min showed the highest iron concentration (0.1513 mg/L) compared to those boiled for longer duration (0.0645 mg/L), pink leaves, and dark red leaves (Awol, 2014). This suggests that shorter boiling times may be more effective in preserving iron content in green sweet potato leaves (Traoré et al., 2017). In contrast, the highest calcium concentration was found in green leaves boiled for more than 10 min, followed by dark red leaves, green leaves boiled for 10 min, and pink leaves, suggesting that prolonged boiling may enhance calcium extraction from green leaves, while dark red leaves naturally have higher calcium content (Tang et al., 2020). Magnesium concentrations remained relatively consistent across all samples, with slight variations; Green leaves boiled for 10 minutes showed the highest magnesium concentration, while pink and dark red leaves showed similar levels, implying that magnesium content is less affected by leaf color or boiling time (Awol, 2014).

The addition of sugar to the boiled extract water for 10 minutes caused the iron content in green leaves to decrease (0.0478 mg/L), while in red leaves it increased (0.0834 mg/L). On the other hand, the calcium content was higher, both in green leaves (0.8425 mg/L) and red leaves (1.2787 mg/L). The addition of sugar to the boiled extract water had a significant impact on the iron and calcium content in green and red leaves (Awol, 2014). Iron concentration decreased in green leaves but increased in red leaves after the addition of sugar, indicating a differential interaction between sugar and leaf pigments in the retention or extraction of iron. However, calcium concentration increased in green and red leaves when sugar was added, indicating a potential synergistic effect between sugar and leaf components in the solubility or release of calcium. The test results data on mineral and vitamin C content in sweet potato leaf water extract are shown in Table 1.

Table 1. Concentration of compounds in water extract of sweet potato leaves

Parameter	Unit	Sweet potato leaf water extract					
		Green leaf		Red leaf		Added sugar	
		Boiled 10 minute	Boiled >10 minute	Pink	Dark red	Green leaf	Dark red leaf
Iron (Fe)	mg/L	0.1513	0.0645	0.0745	0.1101	0.0478	0.0834
Calcium (Ca)	mg/L	0.5420	0.6851	0.2584	0.9583	0.8425	1.2787
Magnesium (Mg)	mg/L	1.9231	1.8911	1.8804	1.9293	1.8971	1.9167

b. Mineral Content in Sweet Potato Leaf Extract

To prepare green and red sweet potato leaf samples for mineral content analysis, a careful process was applied, starting with the collection of about ten leaves from each variety (Awol, 2014). These leaves undergo a thorough cleaning to remove surface contaminants before undergoing a week-long air-drying period, strategically designed to reduce their moisture content and prepare them for subsequent oven drying (Laswai et al., 2011). The drying process continued in a laboratory oven set at a controlled temperature of 105°C for 72 hours, or until a consistent weight was achieved, ensuring complete removal of residual water (Tang et al., 2020). First, the dried leaves were dried at a temperature of 600 oC for 2 hours. The kiln process turned the leaves into ash. After becoming ash, the sample was then added with 20 mL of 1+1 HCL solution (a mixture of HCL and HNO3 1:1), then heated to boiling for 10 minutes and covered with a watch glass. After the heating process, the sample was then cooled and filtered using filter paper. The filtered filtrate was then put into a 50 mL measuring cylinder and distilled water was added to the mark.

Figure 3. Oven process for Sweet Potato Leaves

The results of the analysis revealed significant concentrations of major minerals in sweet potato leaves, with variations observed between green and red varieties. Specifically, the iron concentration in green sweet potato leaves was determined to be 56.3633 µg/g, while in red sweet potato leaves, the concentration was slightly lower at 55.4633 µg/g. Calcium concentrations showed substantial differences between the two samples, with green leaves showing a significantly higher concentration of 1052.22 µg/g compared to red leaves, which had a concentration of 285.9 µg/g. In contrast, magnesium concentrations showed relatively small differences between green and red samples, with values of 33.02 µg/g and 32.46 µg/g, respectively. The quantification of these mineral concentrations underlines the nutritional significance of sweet potato leaves, highlighting their potential contribution to dietary mineral intake. Sweet potato leaves are a good source of minerals, free amino acids, carotenoids, chlorophyll, and vitamin C (Tang et al., 2020).

The observed differences in mineral content between green and red varieties suggest possible variations in the mechanisms of nutrient absorption or accumulation, which may be influenced by genetic factors or environmental conditions. It is known that sweet potato leaves contain essential nutrients comparable to those found in edible wild leaves (Awol, 2014). The concentration of red sweet potato leaf aqueous extract was 1.4784 mg/g, while the concentration of green sweet potato leaf aqueous extract was 4.5320 mg/g. Detailed quantitative data on the concentration of minerals in sweet potato leaves, including iron, calcium, and magnesium, are presented in Table 2. It provides a comprehensive overview of the elemental composition of the analyzed samples.

Table 2. Mineral Concentration in Sweet Potato Leaves

Minerals	Green Leaf Sample (mg/100 g)	Red Leaf Sample (mg/100 g)
Iron (Fe)	5.6	5.5
Calcium (Ca)	105.2	28.6
Magnesium (Mg)	3.3	3.2

Vitamin C content

Examination of vitamin C compounds was carried out at the Agricultural Products Technology (THP) laboratory at the University of Papua. The vitamin compounds were examined in sweet potato leaves by titration. The examination method begins with a 10 ml pipette of diluted sample in an Erlenmeyer flask, followed by the addition of 3 drops of 1% Starch solution. The sample is then titrated with a standard 0.01 N Iodine solution. Stop the titration if the sample color changes to blue, and note the volume of Iodine used. Vitamin C content was calculated using the iodometric titration method based on the volume of iodine consumed during titration. The results of the analysis of vitamin C in boiled sweet potato leaf water are explained in Table 3

Table 3. Results of Vitamin C Analysis in Boiled Sweet Potato Leaf Water

Sample	Volume Iod (mL)				Vit C levels (mg)
	Test 1	Test 2	Test 3	Average	
Red leaves	1.66	1.78	1.60	1.68	1.4784
Green leaves	4.84	5.44	5.16	5.15	4.5320

According to the research results in Table 3, the concentration of vitamin C in the water extract from red sweet potato leaves was 1.4784 mg/g, whereas in green sweet potato leaves, it was 4.5320 mg/g. The concentration of vitamin C in green leaves is higher than in red leaves. The observed differences in vitamin C concentration between red and green sweet potato leaves, with the latter showing significantly higher concentrations, prompted further investigation into the underlying biochemical and genetic factors that regulate the biosynthesis and accumulation of ascorbic acid in these different plant varieties (Laswai et al., 2011). Understanding these factors may be crucial in identifying strategies to enhance the nutritional value of sweet potatoes and optimize their use as a source of vitamin C in food (Koua et al., 2018). The variation in vitamin C content observed between red and green sweet potato leaves may result from differential gene expression patterns related to the ascorbic acid biosynthesis pathway (Ishida et al., 2000).

DISCUSSION

Laboratory analysis has shown that iron and magnesium contents in sweet potato leaves were not affected by leaf color, highlighting a consistent mineral profile across varieties. In contrast, mineral and vitamin C contents in aqueous extracts were susceptible to leaf color, boiling duration, and sugar addition, highlighting the dynamic interactions between these factors and nutrient retention. Variations in calcium, magnesium, and vitamin C concentrations were observed depending on the specific leaf type, highlighting the importance of considering varietal differences in nutritional assessment. A 10-minute boiling period for green leaves resulted in higher iron concentrations compared to longer boiling times, indicating an optimal cooking duration to preserve this essential mineral. However, prolonging the boiling time increased calcium concentrations, indicating a balance between the availability of different minerals. Sugar addition affected iron and calcium concentrations, potentially altering the nutrient composition of leaf extracts, highlighting the complex interactions between food additives and nutrient profiles (Laswai et al., 2011 ; Tang et al., 2020).

Comparative analysis with previous studies on the nutritional content of sweet potato leaves revealed that the iron concentrations in green and red sweet potato leaves from Manokwari (5.6 and 5.5 mg/100 g, respectively) were within the reported range of 1.9-21.8 mg/100 g, corroborating the existing data on iron variability. However, calcium concentrations (105.2 and 28.6 mg/100 g) were lower than the reported range of 229.7-1958.1 mg/100 g, indicating regional or varietal differences in calcium accumulation. Similarly, magnesium concentrations were below the wide literature range of 220.2-910.5 mg/100 g, further emphasizing the variability in mineral content depending on geographical location and cultivar. According to the nutritional quality index, sweet potato leaves are a valuable source of protein, fiber, and minerals, especially K, P, Ca, Mg, Fe, Mn, and Cu, highlighting their potential contribution to dietary requirements. Vitamin C concentrations were also below the literature range of 62.7-81 mg/100 g, indicating potential degradation during processing or variations in analytical methodology (Hiroshi Ishida et al., 2020; Shekhar et al., 2015).

Vitamin C plays a role in the formation of hemoglobin in the blood, in addition vitamin C helps the process of producing red blood cells by absorbing iron from food. In order for iron to be easily absorbed in the body, vitamin C is needed. Vitamin C functions to increase iron absorption by changing the form of ferri to ferro (Krisnanda, 2020). The presence of vitamin C in the blood will also increase the process of iron absorption, because vitamin C can reduce ferri ions to ferro ions. So someone is advised to consume vitamin C and iron (Fe) in a balanced way, so that the process of iron absorption can be maximized. In addition to vitamin C, another type of mineral, magnesium, can also help increase hemoglobin levels. Where there is a positive relationship that is not statistically significant between magnesium intake and hemoglobin levels in adolescent girls who experience anemia with a contribution of 3.72% (Prisma Cahyaning Ratri, 2017; Agustkawati et al., 2022).

Sweet potato leaf decoction showed promising potential to enhance hemoglobin formation, as demonstrated by the analysis of essential mineral concentrations and vitamin C levels. Variations in mineral concentrations in the aqueous extract underscore the significant impact of sweet potato leaf processing methods on the resulting mineral and vitamin C content. Therefore, careful consideration of processing techniques is essential when utilizing sweet potato leaves for consumption (Awol et al., 2014). The clear differences in the nutritional profile, especially regarding mineral and vitamin C concentrations, imply that different processing methods can selectively modulate the efficiency of extraction of essential micronutrients from sweet potato leaves. Furthermore, the choice of leaf type, especially regarding color variations, should be considered as an important factor in optimizing the nutritional value of the decoction. The selection of certain sweet potato leaf cultivars or varieties that are distinguished by their unique color characteristics, can substantially affect the final nutrient composition of the resulting decoction, thus requiring a more refined approach to the preparation and utilization of sweet potato leaf extracts in both culinary and medicinal contexts (Kadir & Herniawati, 2021; Sibuea, 2013).

The interaction between leaf color and nutrient content in sweet potato suggests that the accumulation and distribution of minerals and vitamin C are influenced by physiological and metabolic processes inherent in each leaf type. The processes that vary between green and red leaves may be related to differences in photosynthetic activity, pigment synthesis, or resource allocation within the plant. This suggests that different sweet potato leaf varieties exhibit variation in their inherent capacity to accumulate and retain certain minerals and vitamin C. Furthermore, the potential role of genetic factors in influencing the mineral and vitamin C content of sweet potato leaves should not be overlooked. The inherent genetic makeup of different sweet potato cultivars likely plays an important role in determining the patterns of accumulation and distribution of minerals and vitamin C in their leaf tissues (Rismawati, 2020)

The role of vitamin C as a potent antioxidant in the diet underlines its beneficial effects on human health. Its antioxidant properties neutralize free radicals, thereby reducing oxidative stress and protecting against chronic diseases. Consumption of sweet potato leaf decoction, which is rich in vitamin C, may contribute to overall well-being by enhancing antioxidant defenses. Inclusion of sweet potato leaf decoction in the dietary regimen may serve as a valuable strategy to increase vitamin C intake and strengthen antioxidant protection. The ability of vitamin C to scavenge free radicals and protect cellular components from oxidative damage positions it as an essential nutrient for maintaining overall health and reducing the risk of chronic diseases. Further studies are needed to determine the bioavailability of vitamin C from sweet potato leaf decoction and to assess its impact on various health outcomes (Nguyen et al., 2021).

CONCLUSION

This study has analyzed the mineral and vitamin C content in several preparations of red and green sweet potato leaf water extract. The evaluation results obtained data that have optimal mineral and vitamin content are boiled green sweet potato leaf water extract and green leaf extract. Green sweet potato leaves show higher mineral and vitamin C concentrations compared to red sweet potato leaves, indicating its potential as a more effective food source to overcome malnutrition. The traditional use of sweet potato leaves in treating anemia and improving overall health, while contributing to the development of evidence-based strategies to improve hemoglobin levels in at-risk populations. Optimization of processing techniques coupled with careful selection of sweet potato leaf varieties, has the potential to maximize the nutritional benefits obtained from a widely available resource.

Conflicts of Interest: The authors declare no conflicts of interest related to the publication of this paper.

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