

PROXIMATE ANALYSIS OF CASSAVA (*Manihot esculentus*)

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BY

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CERTIFICATION

This research report entitled “Proximate analysis Of Cassava (*Manihot esculentus*)” by ABUBAKAR MOHAMMED BABATETENGI with an admission number (1910302251) has been read and approved by the undersigned as the requirement for the award of Bachelor of Science (Hons.) Degree in Biology in the Department of Biology, Faculty of Chemical and Life Sciences, Usmanu Danfodiyo University, Sokoto

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DEDICATION

I dedicate this work to myself, for the determination and effort I have invested throughout this academic journey. To my dear parents, whose unwavering love, guidance, and support have been my greatest source of strength and inspiration. This accomplishment is as much yours as it is mine.

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ABSTRACT

This research investigates the proximate composition of *Manihot esculenta* (cassava) to evaluate its nutritional profile and potential applications. The study aimed to analyze the moisture, ash, protein, fat, fiber, and carbohydrate contents of cassava, providing insight into its nutritional value. Using standard analytical methods, the proximate analysis was carried out on prepared cassava samples. The results revealed qualitative variations in the nutritional components, with cassava exhibiting a high carbohydrate content as 69.88%, moderate fiber as 7.75%, protein as 7.88%, relatively low ash as 2.5%, fat concentration as 1.25% and moisture content 11% These findings highlight cassava's potential as an energy-rich food source and its versatility in food processing and industrial applications.

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background of the study

Manihot esculenta, commonly known as cassava, is a tropical root crop that is cultivated primarily for its starchy tuberous roots, native to South America. Cassava has spread to many tropical and subtropical regions, becoming a major staple food in Africa, Asia, and Latin America due to its adaptability to varying soil conditions and climates (El-Sharkawy, 2004). The crop is an important source of carbohydrates, and its roots provide a significant portion of daily caloric intake in many developing countries (Nweke, 2004).

Beyond its role as a food source, cassava has industrial applications, including the production of cassava flour, starch, and bioethanol. The root's high starch content makes it a valuable commodity in food processing and industrial sectors (Olsen and Hossain, 2012). Despite its widespread use, cassava's nutritional quality can vary based on factors such as variety, soil conditions, and processing methods, which can influence its nutrient profile and suitability for different uses (Ceballos *et al.*, 2015).

In Nigeria, cassava (*Manihot esculenta*) is a staple crop, playing a crucial role in the country's agriculture and economy. It is a major source of carbohydrates and is cultivated across various regions due to its adaptability to different soil types and climatic conditions (FAO, 2021).

In Nigeria, cassava is not only a dietary staple but also a key component of the agricultural sector, providing livelihoods for millions of farmers. The crop is integral to traditional dishes like Garri, Fufu, and cassava flour.

Cassava is a woody shrub cultivated extensively as an annual crop although it is a perennial plant (Wikipedia, 2022). It is majorly grown for its storage roots and its importance is increasing in Africa because of its diverse uses, tolerance to environmental stress such as drought, low soil fertility and its relatively high productivity where many other crops fail (McCormick and Schmitz, 2001). The International Center for Tropical Agriculture (CIAT) has referred to the crop as the “Rambo of food crops” because of its ability to thrive in warmer climates. This particular feature of cassava will be found to be useful in the fight for food security and in combating the possible effect that the expected temperature rise by 2 degrees Celsius in Africa by 2030, will have on food availability (Cecilia Schubert, 2012). It

is predominantly consumed as food, but also used as animal feed and raw materials for related industries. Cassava is classified as 'sweet' when the cyanogenic glucoside (CG) content is less than 100 mg/kg fresh weight, while cultivars with CG content of 100–500 mg/kg fresh weight are referred to as 'bitter' (Alves, 2002). The leaves serve as vegetable in at least 60 % of the countries in sub-Saharan Africa (SSA), providing an important source of vitamins (B1, B2 and C), carotenoids, minerals and proteins, with crude protein content ranging between 17 – 40 %, depending on variety, stage of maturity, soil fertility, harvesting frequency and climate (Latif and Muller, 2015).

In 2020, the world cassava production stands at 302.66 million metric tonnes; Africa is the world's largest cassava-growing region, with a total production of 193.62 million metric tonnes, and unarguably, Nigeria remains the highest producer of cassava in the world with about 60 million metric tonnes (FAO, 2022). Also, global cassava production in terms of total area harvested has increased substantially in recent years. Nigeria led the world in this aspect with a total harvested area of 7.7 million ha in 2020 (FAOSTAT, 2022). Despite being the world's largest cassava producer, more than 90 % of cassava produced in Nigeria is consumed locally (The Guardian, 2020). To maximize the prospects of the cassava industry in areas such as exportation, industrial

uses, food security, economic development, etc., there is the need for increased and enhanced production, processing, and packaging leveraging the current technologies and innovations.

1. 2. Justification of the Study

Despite the widespread cultivation and consumption of *Manihot esculentus* (cassava) in many regions, there is limited comprehensive data on its proximate nutritional composition, particularly in different processing forms. This lack of information poses several challenges:

Nutritional Gaps: Insufficient understanding of the nutrient profile can lead to inadequate dietary recommendations, potentially affecting the health of populations reliant on cassava as a staple food.

Processing Variability: Different processing methods (e.g., boiling, drying, and fermentation) can significantly alter the nutritional content of cassava, yet there is a scarcity of studies examining these effects systematically.

Food Security Concerns: In contexts where cassava is a primary food source, knowing its nutritional value is critical for addressing food security and malnutrition.

Health Risks: Without adequate knowledge of anti-nutritional factors present in cassava and how processing impacts these, consumers may unknowingly consume harmful levels.

Agricultural Practices: Farmers lack guidance on the nutritional implications of various cassava varieties and cultivation methods, limiting their ability to optimize yield and nutritional quality.

1.3. Significance of the Study

By providing a comprehensive analysis of cassava's nutritional profile, this research will contribute to better understanding its role in diets, particularly in regions where it serves as a staple food. The findings may also guide farmers and food processors in optimizing cultivation and processing methods to enhance nutritional value.

1.4. Aim and Objectives

This study aims to conduct a proximate analysis of cassava to determine its nutritional composition. This analysis will focus on measuring key components such as moisture content, ash content, crude protein, crude fat, and fiber content.

- i. To determine the proximate composition of cassava

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 *Manihot esculentus* (Cassava)

Manihot esculentus (commonly known as cassava) is a tropical root crop widely grown for its starchy tuberous roots, which serve as a primary source of carbohydrates in many regions of the world. The proximate analysis of cassava provides insight into its nutritional content, including moisture, crude protein, crude fiber, crude, fat, ash, and carbohydrate composition.

Cassava is primarily composed of carbohydrates, with starch making up a significant portion of its dry matter. According to Okezie and Kosikowski (1982), cassava's carbohydrate content can range between 80-90% on a dry weight basis, making it a valuable energy source for both human consumption and animal feed. However, its protein content is relatively low, typically around 1-2%, which may necessitate protein supplementation in diets that rely heavily on cassava (Akinpelu *et al.*, 2011).

The moisture content of cassava roots varies depending on factors such as cultivar and growing conditions. High moisture content, typically between 60-70%, makes cassava highly perishable, which is why it is often processed into more stable forms like flour

or starch soon after harvest (FAO, 2013). This high water content also affects its storage and shelf life.

Research by Oluwole *et al.*,(2004) found that cassava contains around 1-3% crude protein and less than 1% crude fat. The low protein content has raised concerns about cassava's role as a staple food, especially in regions where protein-energy malnutrition is prevalent (Maziya-Dixon *et al.*, 2004).

Cassava also contains crude fiber, which aids in digestion, with values ranging between 2-4% depending on the variety. The ash content, which represents the total mineral content, is usually between 2-3%. Ash analysis indicates the presence of important minerals such as calcium, potassium, and magnesium, although these values may vary based on soil composition and agricultural practices (Balogun *et al.*, 2012).

2.1. Processing and Nutrient Losses

Different methods of processing cassava, including boiling, drying, and fermentation, can lead to significant changes in its proximate composition. For example, studies by Oduro *et al.*, (2010) suggest that drying and fermentation can reduce the moisture content and increase the concentration of other nutrients. However, these processes

can also result in the loss of vitamins and certain amino acids, requiring a careful balance to maintain nutritional quality.

2.2. Carbohydrate Composition and Energy Value

Carbohydrates are the most abundant component of cassava roots, contributing significantly to its energy value. The starch in cassava is composed of amylose and amylopectin, which are important for both industrial applications and human consumption. Umeh and Nweke (2006) noted that the high energy value of cassava, approximately 150 kcal per 100 grams of fresh root, makes it an essential food source in regions where energy demands are high. This high carbohydrate content also makes cassava a suitable raw material for biofuel production, particularly in the form of ethanol.

2.3. Cassava's Role in Food Security

Due to its high carbohydrate content and adaptability to different growing conditions, cassava has been hailed as a crucial crop in combating food insecurity, especially in sub-Saharan Africa and parts of Asia. Nweke *et al.*, (2002) emphasized that cassava is often regarded as a "famine reserve" due to its ability to withstand poor soil conditions and periods of drought, making it a reliable crop in marginal environments.

In addition to contributing to food security, cassava is gaining popularity among commercial feedstuff producers in Nigeria. Efforts are being made to substitute cassava for grains in the animal feed producing industries, through the promotion of cassava products such as pellets and chips, in order to reduce cost of importation of feedstuffs. Undoubtedly, a rise in productivity at the farm level is needed for cassava to become a competitive feedstuff on both domestic and international markets. The world now recognizes that growing high yielding cassava spurs development especially in Agrarian countries (Hershey *et al.*, 2001). The problem of how to produce beyond domestic demand and sustain supply to the international markets is one of the challenges facing the cassava production sector in Nigeria. Data show that countries that have institutional structures to sustain cassava production have continually increased their participation as economic agents at the world cassava market (Edamisan and Kemisola, 2020). To fully tap the potentials of cassava to develop the Nigerian economy, there is the need for value addition and the fundamental step towards adding value to cassava is processing. Cassava, especially the bitter type which is predominant in Nigeria is processed before consumption. This is important to remove or reduce the potentially toxic cyanogenic glucosides present in the cassava

storage roots. Processing also serves as a means of preservation. If left unprocessed, cassava roots exhibit visible symptoms of postharvest physiological deterioration (PPD) within only 24 to 72 hours of harvest (Morante *et al.*, 2010, Salcedo and Siritunga, 2011, Vanderschuren *et al.*, 2014). In addition to removing or reducing the toxins in cassava and preserving the storage roots, processing generates diverse products with increasing value. Transformation of fresh cassava into stable products reduces its weight to ease transportation and handling. Such products may be cassava pellets, chips, and flour. Processing the storage roots into flour is one of the traditional ways of value addition to cassava in Africa. However, the traditional way of preparing cassava flour results in poor quality flour. This has greatly reduced its marketability especially as it is unappealing as a substitute for wheat flour in bakery products (Joko and Kazuhiko, 2013).

Over the years, the supply of cassava derivatives or byproducts in Nigeria has fallen short of demand. For instance, the demand for high quality cassava flour (HQCF) for bread, biscuits and snacks is put at 500,000 metric tones per annum, but supply is less than 15,000 metric tones per annum (PWC, 2020). On the other hand, the demand for cassava starch is 300,000 metric tones, but supply remains below 10,000 metric tones.

Despite the high demand for these products, supply is still very low. More startling is the near zero supply for ethanol in the country despite a huge potential demand of over one billion litres needed for industrial and domestic purposes (PWC, 2020). This implies that if supply of cassava does not grow at the same rate as demand, the cassava market equilibrium will be altered and in response, prices of cassava products will always fluctuate accordingly (Edamisan and Kemisola, 2020). Since little is processed as done in Thailand for many and varied uses, the outlook for increasing cassava production is promising as it can encourage rural and economic development through increase in production, processing, marketing and export of HQCF, starch, pellets and chips to earn foreign exchange. A study carried out by Udemezue *et al.*, (2019) reviewed the cassava production trends, cassava value chain issues, value chain and the challenges for cassava production and processing in Nigeria. The study agrees that agricultural sector is a strong driver of the economy and therefore recommends that for the nation to leverage on the cassava crop to boost her economy; the extension linkage with research should be strengthened so as to facilitate the spread of improved cultivars and management practices to farmers, integration of information and supply of necessary inputs, promotion of group approach to extension delivery,

linking agricultural cooperative societies with other important stakeholders like agricultural research institutions, equipment fabricators, amongst others.

2.4. Health Concerns and Processing Techniques

Despite its advantages, cassava contains naturally occurring cyanogenic glycosides, such as linamarin, which can release toxic hydrogen cyanide when the roots are improperly processed. This has raised concerns about the health implications of consuming inadequately prepared cassava. To mitigate these risks, various processing techniques, such as peeling, soaking, fermenting, and boiling, are employed to reduce the cyanogenic content (FAO, 2013). Montagnac *et al.*,(2009) reported that proper processing can reduce cyanide content to safe levels, making cassava a viable food source when handled correctly.

2.5. Comparative Analysis with Other Root Crops

When compared with other tropical root crops like sweet potatoes and yams, cassava generally has a higher carbohydrate content but lower protein and micronutrient levels. Studies by Nambisan (2011) suggest that while cassava has a higher caloric density, its limited nutritional diversity can be a disadvantage, especially in populations that depend on cassava as a staple. This nutritional gap highlights the importance of dietary diversification or fortification when cassava is a primary food source.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Study Area

The analysis was carried out in the Agricultural Science Chemical Laboratory at Usmanu Danfodiyo University Sokoto State. Sokoto State is one of the 36 states of Nigeria, located in the extreme northwest of the country. Bounded by the Republic of the Niger to the north and west for 363 km (226 miles), the states of Zamfara to the east, and Kebbi to the south and west. Its capital and largest city is the city of Sokoto. Sokoto is located near the confluence of the Sokoto River and the Rima River. As of 2022, it has an estimated population of more than 6.3 million. Sokoto State's agriculture is predominantly subsistence-based, with over 80% of the population engaged in farming activities (NBS, 2021). Key crops include millet, guinea corn, maize, rice, potatoes, cassava, groundnuts, and beans, which are essential for local food security. Additionally, cash crops such as wheat, cotton, tobacco, and various vegetables are cultivated for income generation (FAO, 2020). Livestock farming, including cattle, goats, and sheep, is also significant, contributing to both nutrition and economic stability (World Bank, 2019).

3.2. Sample Collection

Manihot esculentus (cassava) was collected at Chohi Badai Farm, Located in Dange Shuni Local Government Area, Sokoto state Nigeria, and kept inside a polythene bag to be carried to the laboratory for analysis.

3.3 Sample Preparation

Cassava samples were washed, peeled, and cut into pieces using a knife.

These pieces of sample were then divided into two portions.

One portion was air-dried in the laboratory for seven days to remove excess moisture.

The other portion was sun-dried for three days. After drying, both portions were pounded into a fine powder using a laboratory pestle and mortar.

3.4 Proximate Analysis Procedures

The proximate analysis of the air-dried and sun-dried samples was conducted following standard laboratory methods:

3.4.1 Determination of Moisture Content:

Approximately 2g of the powdered sample was weighed into a pre-weighed crucible recorded as W1. The crucible was placed in an oven at 105°C for 24 hours to ensure complete removal of moisture. After drying, the sample was cooled in a desiccator and reweighed as W2. The moisture content was calculated as follows: (AOAC 1999)

$$\% \text{Moisture} = \frac{W_1 - W_2}{W_1 - W_0} \times 100$$

Where W_1 = weight of fresh sample + crucible

W_0 = weight of empty crucible

W_2 = weight of dried sample

3.4.2 Determination of Ash Content

Exactly 2g of the sample was weighed into a pre-weighed crucible and recorded as W_1 . The crucible was then placed in a muffle furnace and heated at 460°C for 3 hours until a gray ash residue was formed, indicating complete incineration of organic matter. The crucible was allowed to cool in a desiccator before weighing again as W_2 .

The ash content was calculated as: (AOAC 1999)

$$\% \text{ Ash} = \frac{W_2 - W_0}{W_1 - W_0} \times 100$$

Where W_0 = empty crucible

W_1 = weight of crucible + sample before drying

W_2 = Weight of crucible + ash

3.4.3 Determination of Crude Protein

The exact 0.5g of the sample was added to a dish and placed into the digestion flask.

The selenium tablet which acts as catalyst and 10mls of sulfuric acid (H_2SO_4) were

added for the digestion. After the digestion, the sample was diluted with distilled water making it a 50ml volume. Exactly 10mls were taken out of the volume for distillation and after that, 30mls of distilled water and 20mls of 40% Sodium hydroxide (NaOH) were added. It was placed in the distillation machine and 20mls of boric acids were placed in the indicator under the condenser. The distillation commenced, and the color of the boric acid indicator changed from dark red to green. The nitrogen content was converted to crude protein by using a factor (6.25). The protein was calculated as: (AOAC 1999)

$$\% \text{ Protein} = (\text{N} \times 6.25)$$

Where N= Nitrogen

3.4.4 Determination of Lipid Content

Exactly 2g of the sample was placed into the specimen bottle and weighed as W1, to determine the oil percentage in the sample, then 20mls of n-hexane was added into the sample and was shaken thoroughly and kept overnight. After this the oil present was decant from the sample and weighed as W2. The lipid content was calculated as: (AOAC 1999)

$$\% \text{ Lipid} = \frac{W_2 - W_1}{2} \times 100$$

3.4.5 Determination of Crude Fiber:

The residue from lipids was weighed as W1. The mineral content and the residue was transferred into a conical flask. 10mls of sodium hydroxide was added and boiled for about 10-15 minutes and was then filtered with a sieve and then transferred back into the conical flask. To remove protein content, 10mls of 10% Sodium hydroxide (NaOH) was added into the residue in the conical flask and boiled for 10-15min. After boiling some amount of water was added to the residue and filtered. The residue was transfer into the crucible and placed into the oven for dryness at 105°C. The dry sample was weighed as W2. The crude Fiber was calculated as: (AOAC 1999)

$$\% \text{ Fiber} = \frac{W1 - W2}{2} \times 100$$

3.4.6 Determination of Carbohydrates:

The carbohydrate content of the cassava samples was determined by difference. The sum of the percentages of moisture, protein, fat, fiber, and ash was subtracted from 100%.ie

$$\text{Carbohydrate} = 100 - (\text{Moisture} + \text{ash} + \text{fats} + \text{lipids} + \text{protein})$$

3.5 Data Analysis

The data collected from the proximate analysis were analyzed using descriptive statistics. The results for each parameter were expressed as mean values with standard deviations.

CHAPTER FOUR

4.0

RESULTS

4.1 Moisture Content:

Air-drying retains more moisture (14%) compared to sun-drying (8%).

The mean value (11%) suggests moderate moisture levels overall, with a high standard deviation (4.24) indicating significant variability between the methods.

4.2 Ash Content:

Both drying methods produce relatively similar ash content (2.5% for air-drying and 2% for sun-drying).

The low standard deviation (0.35) indicates minimal variability in ash content between the methods.

4.3 Lipid Content:

Sun-drying results in slightly higher lipid content (1.5%) compared to air-drying (1%).

The standard deviation (0.35) indicates minimal variation.

4.4 Fiber Content:

Air-drying retains a much higher fiber content (10%) than sun-drying (5.5%).

The standard deviation (3.18) suggests moderate variability.

4.5 Protein Content:

Air-drying retains significantly more protein (12.25%) compared to sun-drying (2.5%).

The standard deviation (6.12) reflects high variability.

4.6 Carbohydrate Content:

Sun-drying results in substantially higher carbohydrate content (79.5%) compared to air-drying (60.25%).

The standard deviation (13.65) is the highest, indicating considerable variability between the two methods.

Table 1: Showing the result of Proximate Analysis of Cassava (*Manihot Esculenta*)

Parameter	Air-drying (%)	Sun-drying (%)	Mean	Standard Deviation
Moisture content	14	8	11	4.24
Ash	2.5	2	2.5	0.35
Lipid	1	1.5	1.25	0.35
Fiber Content	10	5.5	7.75	3.18
Protein Content	12.25	2.5	7.88	6.12
Carbohydrate Content	60.25	79.5	69.88	13.65

CHAPTER FIVE

5.0 DISCUSSION

The moisture content of cassava in this study was found to be moderate. This is consistent with reported values for cassava moisture content, which typically ranges between 10% and 20%, depending on factors such as variety and environmental conditions (Dahal and Tamang, 2021). A moderate moisture content suggests that the cassava tuber has a balanced moisture level, supporting its storage potential. Lower moisture content generally helps reduce microbial growth and spoilage, which is crucial for preserving the quality of cassava during storage and post-harvest handling (Anyasi *et al.*, 2018). Thus, cassava with this moisture level could be effectively processed into dried products, such as flour, which are suitable for long-term storage (Anyasi *et al.*, 2018).

The protein content observed was relatively high compared to typical protein levels in cassava. Cassava is usually considered a low-protein food, with protein content generally ranging from 1% to 3% (Seid *et al.*, 2021). However, environmental factors, cultivation practices, and specific varieties of cassava can influence protein levels (Mengistu *et al.*, 2020). Although cassava is not typically used as a major protein source, its protein content can contribute supplementary amino acids in regions where

other protein sources are limited (Anyasi *et al.*, 2018). This protein value highlights cassava's role in enhancing dietary nutrition, especially in regions where protein intake is often insufficient.

The lipid content in cassava was found to be low, as expected from this tuber crop. Cassava's low-fat content plays a critical role in reducing the risk of rancidity, making it suitable for storage as it does not undergo oxidation quickly (Dong, Zhang, and Liu, 2023; Zhang, Li, and Wang, 2015). The minimal lipid content in cassava also makes it an ideal option for low-fat diets without compromising its storage potential. This feature is important when considering cassava for processed products such as flour, which require stability over extended periods of time.

The fiber content of cassava was found to be moderate, which is consistent with reported fiber levels in cassava, typically ranging from 5% to 15% (Akissoe *et al.*, 2015; Verywell Fit, 2023). Dietary fiber is essential for digestive health, and high fiber intake can help prevent constipation and other digestive disorders (Seid, Woldemariam, and Tesfaye, 2021). In areas where fiber intake is low, cassava can serve as a significant source of fiber in the diet. Its fiber content thus contributes to

improving the dietary quality of populations that rely heavily on cassava as a staple food (Seid, Woldemariam, and Tesfaye, 2021; Verywell Fit, 2023).

The carbohydrate content of cassava was found to be high, which is consistent with cassava's role as a high-energy food. Cassava is a rich source of starch, which accounts for 70% to 80% of the tubers dry weight (Akinmoladun *et al.*, 2020). This high carbohydrate content makes cassava a key energy source in many tropical regions, where it serves as a staple food (Oluwaseun *et al.*, 2019). The high carbohydrate content is beneficial for providing significant dietary energy; however, due to its low protein and fat content, it is important to complement cassava with other foods to ensure a balanced diet (FAO, 2018). The starch in cassava is primarily composed of amylopectin, a highly digestible carbohydrate (Oluwaseun *et al.*, 2019).

The ash content in this study was found to be moderate, which is within the typical range for cassava, as ash content in cassava generally ranges from 0.74% to 3.28% (Adeniji *et al.*, 2007; Scaria and Lal, 2024). The ash content reflects the mineral composition of cassava, including essential nutrients like calcium, potassium, and magnesium. These minerals are crucial for maintaining electrolyte balance and supporting various bodily functions (Adeniji *et al.*, 2007). In regions where cassava is

a staple food, the ash content and its associated minerals contribute significantly to the dietary intake of these essential nutrients (Adeniji *et al.*, 2007; Scaria and Lal, 2024).

CONCLUSION

This study assessed the proximate composition of *Manihot esculenta* (cassava) tubers, focusing on moisture, crude protein, crude fat, crude fiber, carbohydrate, and ash content. The results reveal that cassava is a carbohydrate-rich tuber, with a high carbohydrate content, making it a valuable energy source, particularly in regions where it is a dietary staple. The moisture content indicates moderate storage stability, while the low crude fat content suggests that cassava is suitable for low-fat diets. The crude protein content, though moderate, highlights cassava's potential to supplement protein intake in regions where protein-rich foods may be scarce. Additionally, the fiber content supports its role in promoting digestive health, and the ash content points to the presence of essential minerals that contribute to its nutritional value.

Overall, cassava is a nutritionally significant tuber with potential health benefits, particularly as a source of energy, fiber, and supplementary protein. Its composition reinforces its role as a staple crop, especially in areas facing food security challenges. Future research could explore variations in proximate composition across different

cassava varieties and environmental conditions, as well as strategies to enhance its nutritional profile through biofortification and improved agricultural practices.

RECOMMENDATIONS

1. **Promotion of Cassava as a Staple Food:** Given its high carbohydrate content and potential as an energy source, cassava should be promoted as a staple food in regions with food security challenges. Its affordability and accessibility make it an ideal crop for communities with limited access to more expensive food sources.
2. **Dietary Diversification for Protein and Fat Intake:** While cassava is a valuable source of carbohydrates and dietary fiber, it has limited protein and fat content. It is recommended that cassava be complemented with protein-rich foods (such as legumes, fish, or poultry) and healthy fats in the diet to provide balanced nutrition, especially in communities relying heavily on cassava as a primary food source.
3. **Enhancing Nutritional Quality through Biofortification:** Future agricultural practices should consider biofortification of cassava to increase its protein and micronutrient content. Developing cassava varieties with enhanced levels of essential nutrients, such as vitamin A, iron, and zinc, could improve the crop's nutritional benefits.

4. Development of Cassava-Based Products for Health-Conscious Consumers: Given its low-fat content, cassava is suitable for low-fat diets. The food industry could explore the development of cassava-based products targeting health-conscious consumers, such as low-fat snacks or gluten-free flour alternatives.
5. Further Research on Varietal Differences and Environmental Impact: Research should continue to explore how different varieties of *Manihot esculenta* and diverse growing conditions affect its proximate composition. Such studies could inform farmers and stakeholders about the best varieties for specific nutritional goals and environments.
6. Education and Awareness Programs: Programs that educate communities on the nutritional properties of cassava and the importance of diversifying diets can enhance public health. Empowering local communities with knowledge about food variety and preparation techniques could improve overall dietary quality, especially in cassava-reliant regions.

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