Confluence Journal of Pure and Applied Sciences, Volume 5 Issue 1, March, 2026 Pp 70-90

ORIGINAL RESEARCH

Analytical Exploration of the Nutritional Composition of Leaves from TME419, IBA980581 and CR36-5 Cassava Varieties

Ataguba, E.[1*], Atebije, C.[1], Okpe, J. M.[2], Umar, O. M.[3] and Shaibu, V. N.[4]

[1]Department of Biochemistry, Faculty of Life Science, Federal University, Lokoja, Kogi State, Nigeria. [2]Department of Biochemistry, Federal University of Health Sciences, Otukpo, Benue State, Nigeria. [3] Department of Agricultural Extension, Faculty of Agriculture, PAAU, Kogi State, Nigeria. [4]Department of Science Laboratory Technology, Kogi State Polytechnic, Lokoja, Nigeria.

***Corresponding Author:** eleinthehouse@gmail.com / ele-ojo.ataguba@fulokoja.edu.ng; Phone: +234 814 220 6088.

ABSTRACT

This study presents a comparative analysis of the proximate composition of leaves from three varieties of cassava (*Manihot esculenta*). The objectives were to evaluate and compare the nutritional profiles of TME419, IBA980581 (Dixon) and CR36-5 (Ayaya: beautiful) cassava variety leaves and to identify the similarities and differences in their nutritional value. 1500g leaves each of cassava were carefully collected and identified by an agriculturist as TME 419, IBA980581 and CR36-5 leaves. The leaves were washed with distilled water and air dried for 14 days and thereafter pulverized. Proximate composition was assessed using standard analytical methods to determine the content of moisture, ash, protein, lipid, fiber, and carbohydrates in the leaves of the three cassava varieties. Results indicated significant variations in the levels of these components among the varieties. CR36-5 leaves were shown to be richer in protein (30.56 ± 0.33 %), fiber (33.5 ± 0.14 %) and lipids (3.42 ± 0.08 %) which suggests its potential for enhanced nutritional benefits while TME419 leaves showed richness in carbohydrates (30.04 ± 0.75 %). IBA980581 however, showed a balance in nutritional contents in between the other two cassava varieties. These findings offer opportunities for targeted cassava leaf utilization in human nutrition or animal feed. Future research should explore anti-nutritional factors in these selected varieties, as processing can mitigate them while preserving nutrients, as demonstrated in recent studies. These findings have implications for selecting the leaf of cassava varieties for nutritional purposes and can guide agricultural practices and food security strategies. The study underscores the importance of varietal selection in optimizing the nutritional value of cassava leaves, which are a vital source of dietary nutrients in many regions.

Keywords: cassava, moisture, CR36-5, IBA980581, TME419.

INTRODUCTION

Cassava (*Manihot esculenta*) serves as a staple food for millions of people worldwide, offering more than just starchy tubers. Cassava leaves, often overlooked, holds immense potential as a rich source of protein, vitamins, and minerals (Akinwade et al., 2019). Research suggests they are favorably comparable with other green vegetables in terms of nutrient content (Alamu et al.,2021). However, the exact nutritional profile can vary depending on several factors, including cultivar type, geographical location, growth stage, and processing methods employed (Oboh et al., 2015). A comparative analysis of the proximate composition of cassava leaves sheds light on these variations, providing valuable insights. Cassava leaves are consumed as a vegetable in at least 60% of countries in sub-Saharan Africa and some Asian countries such as Indonesia, Philippines and Malaysia (Achidi et al., 2005). In almost all cassava growing African countries, from Senegal to Mozambique, cassava leaves are consumed at varying levels as a source of protein and micronutrients, depending on cultivar and recipes. In Central Africa, people enjoy eating cassava leaves (Alamu et al., 2022)

According to Bayata (2019), if properly detoxified, cassava leaves could act as an important supplement to prevalent starchy diets, promoting dietary diversity. However, their consumption also raises concerns due to the presence of anti-nutrients and cyanogenic glycosides, which require proper detoxification procedures. These anti-nutrients, including cyanide, oxalate, phytate, tannin, and trypsin inhibitor, can interfere with the absorption of essential nutrients. Among these, cyanide poses more concern due to its toxicity, potentially restricting the consumption of both cassava tubers and leaves Additionally, cassava leaves may have low digestibility, potentially attributed to high fiber content, tannins, and limitations in amino acid availability (Terefe et al., 2022).

According to the report of Adetunji et al. (2023), cassava leaves contain 15 to 20 times more cyanide than the tubers. Therefore, cassava leaves were not widely used as a food source as compared to the tubers part, which was produced into varieties of food products. Moreover, cassava leaves are particularly low in the sulfur-containing amino acids methionine and cysteine which are required to detoxify the cyanogen in human body. Nevertheless, a proper pretreatment process can reduce the presence of anti-nutrient present in cassava leaves before it can be safely consumed (Boukhers et al., 2022).

MATERIALS AND METHODS

Collection and Identification of Plant Sample

Three varieties of cassava leaves, each with an average weight of 1500 ± 0.50g, were sourced from the Kogi State Network of Cassava Seed Entrepreneurs' farm (Basics II project), supported by IITA and Catholic Relief Services (CRS). These leaves were collected in September 2024 at GPS coordinates 7.5521774, 6.6155641 (Ajaokuta; Kogi Central; North Central, Nigeria). The varieties were identified by a Botanist in the Department of Botany, Federal University Lokoja as TME 419, IBA980581 (Dixon) and CR36-5 (Ayaya: Beautiful).

Sample preparation

1500g each of TME 419, IBA980581 and CR36-5 leaves were carefully washed with distilled water and spread on a clean flat surface away from sunlight, close to the window in the laboratory for 14 days to enhance air drying. After 14 days of drying, the leaves were pulverized using the laboratory mortar and pestle until it became smooth and thereafter, packaged and properly labeled awaiting analysis.

Determination of moisture content

The moisture content of the pulverized cassava leaf varieties was determined using the method of AOAC 962.09 (2023) and ISO 712 :(2023). A clean crucible was dried to a constant weight in a hot air oven at 105°C, cooled in a desiccator, and weighed (W_1). Approximately 2 g of the leaf sample was placed into the crucible and weighed again (W_2). The sample was then dried in the oven at 105°C for 8 hours, cooled in a desiccator, and reweighed (W_3).

Moisture content was calculated as follows:

$$\%\ \text{Moisture content} = \text{W2} - \text{W3}/\ W2 - W1\ X\ 100$$

Where W1= weight of empty crucible, W2 = weight of empty crucible + sample before oven drying and W3 = weight of empty crucible + sample after oven drying.

Confluence Journal of Pure and Applied Sciences, Volume 5 Issue 1, March, 2026 Pp 70-90

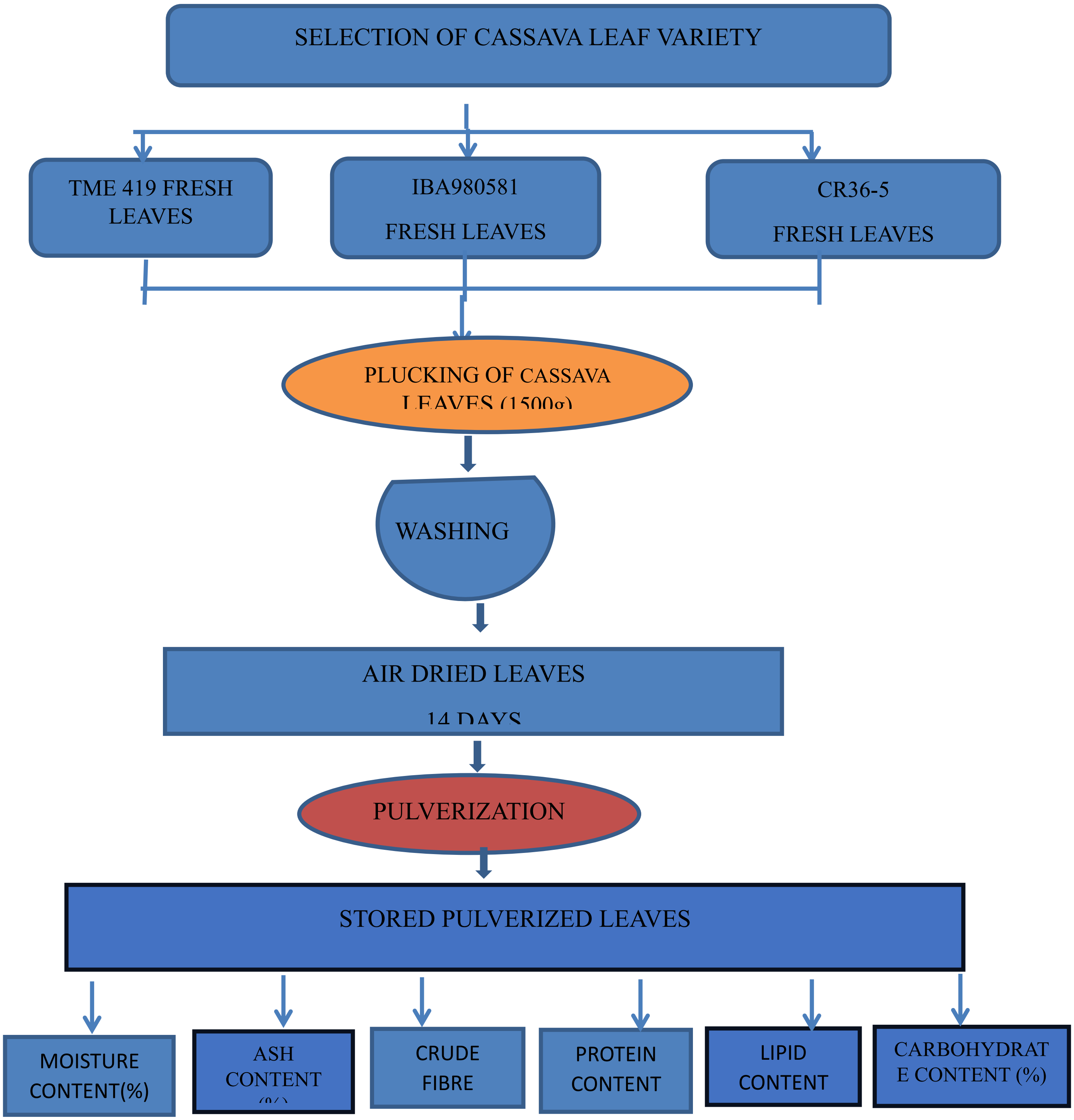

Figure 1: **Flow Chart for the Exploration of the Nutritional Composition of Leave.**

Determination of Ash Content

Ash content was determined according to Idris et al. (2021) and ISO 2171:(2023). A clean crucible was dried to a constant weight, ignited in a muffle furnace at 550°C for 1 hour, cooled in a desiccator, and weighed (W_1). About 2 g of finely ground sample was weighed into the crucible (W_2) and incinerated in a muffle furnace. The temperature was gradually raised to 550°C and maintained for 8 hours to ensure complete oxidation of organic matter. The crucible was then cooled to 220°C, transferred to a desiccator, and weighed after reaching constant weight (W_3).
The ash content was calculated as follows:

$$\%\ \text{Ash} = (\text{Loss of weight}/\ weight\ of\ sample)\ X\ 100$$

$$\%\ \text{Ash} = (\text{W3} - \text{W1}/\text{W2} - \text{W1})\ \text{X}\ 100$$

Where W_1 = weight of empty crucible, W_2 = weight of sample in crucible before incineration and W_3 = weight of sample in crucible after incineration.

Determination of Crude Fiber

Crude fiber was determined using Edet et al. (2023) and ISO 5498: (2020). About 2 g of finely ground sample was weighed into a round-bottom flask. 0.255 M sulfuric acid (H_2SO_4) was added and the mixture refluxed for 30 minutes. The hot solution was filtered, and the residue washed several times with hot distilled water until acid-free. The residue was then transferred into a flask, and 0.313 M sodium hydroxide (NaOH) was added and refluxed for another 30 minutes. It was filtered again and washed until base-free. The residue was dried at 100°C to constant weight (C_2), then incinerated in a muffle furnace at 550°C for 2 hours and reweighed (C_3). Crude fiber content was calculated as:

$$\%\ \text{Crude Fiber}\ =\ (\text{C}_2\ -\ \text{C}_3)\ /\ \text{W}\ \times\ 100$$

Where W = weight of original sample. (C_2 - C_3) = the loss in weight on washing (incineration)

Determination of Lipid Content

The lipid content was determined using the Soxhlet extraction method in accordance with AOAC 920.39 (2019) and ISO 659: (2021). About 2g of the powdered sample was weighed into a pre-weighed extraction thimble (W_1) and extracted with petroleum ether (boiling point 40–60°C) in a Soxhlet apparatus for 8 hours. The solvent was evaporated, and the thimble was dried in an oven at 70°C to a constant weight (W_3).

Lipid content was calculated as:

% lipid (w/w) = (weight of lipid extracted/ weight of direct sample) X 100

% lipid (w/w) = (W_3-W_1 / W_2-W_1) X 100

Where weight of lipid extracted (crude fat) is given by loss in weight (W2-W1) of the thimble content after extraction.

Determination of Crude Protein Content

Protein content was determined using Boyer's (2020) modification of the micro-Kjeldahl method. 12.5 mL of amino acid solution was pipetted into a conical flask, and 3 drops of phenolphthalein indicator were added. Sodium hydroxide (NaOH) was used to neutralize the solution until a faint pink color appeared. 15 mL of neutralized formaldehyde was added, and titration was continued until the pink coloration disappeared. The process was repeated in triplicate, and crude protein was calculated based on nitrogen equivalence, using a conversion factor of 6.25.

Determination of Carbohydrate Content

Total carbohydrate content was determined by difference, following AOAC (2019) and ISO 1871: (2022). The percentage carbohydrate was obtained using the formula:
% Carbohydrate = 100 - (% Moisture + % Ash + % Lipid + % Protein + % Fiber)

Statistical Analysis

The data was analyzed in triplicates by one-way ANOVA using Minitab statistical version 23 software. Significant means were separated using a post hoc at $P < 0.05$ significance level. Experimental results were expressed as mean ± standard error of the mean (SEM).

RESULTS

The result of this present research revealed that each cassava variety exhibits distinct nutritional profiles. **CR36-5** was found to be relatively high in protein, crude fiber, and lipids but lower in carbohydrates and moisture content**. IBA980581** has higher moisture and ash content, with moderate levels of other components. **TME 419** has high carbohydrate content and lower protein, fiber, and lipid levels.

The result of this present research revealed that IBA980581 and TME419 showed no significant difference in moisture content but were found to be significantly higher than CR36-5 which had the lowest moisture content.

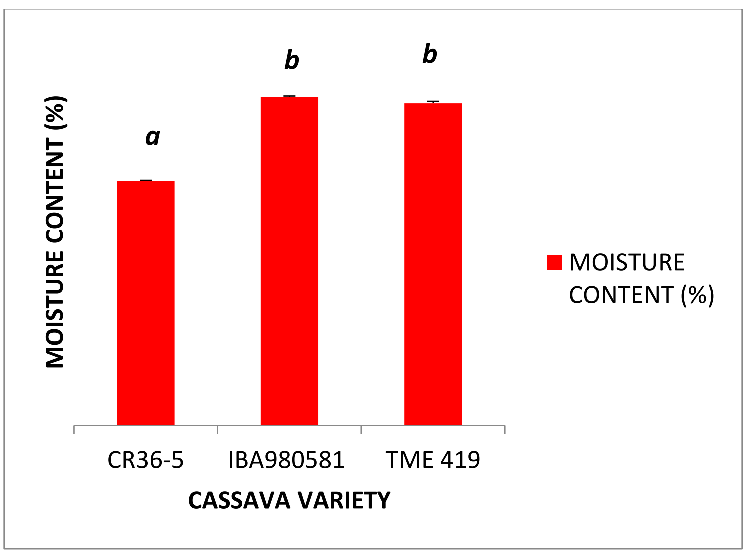

Figure 2: **Graph of comparative analysis of moisture content of Leaves of TME419, IBA980581 and CR36-5 cassava varieties. Key: Values are expressed as mean ± SEM (n = 3). Bars with different superscripts (a, b, c) are significantly different at (p<0.05).**

The result of this present research revealed that the three cassava varieties showed no significant difference to one another in ash content.

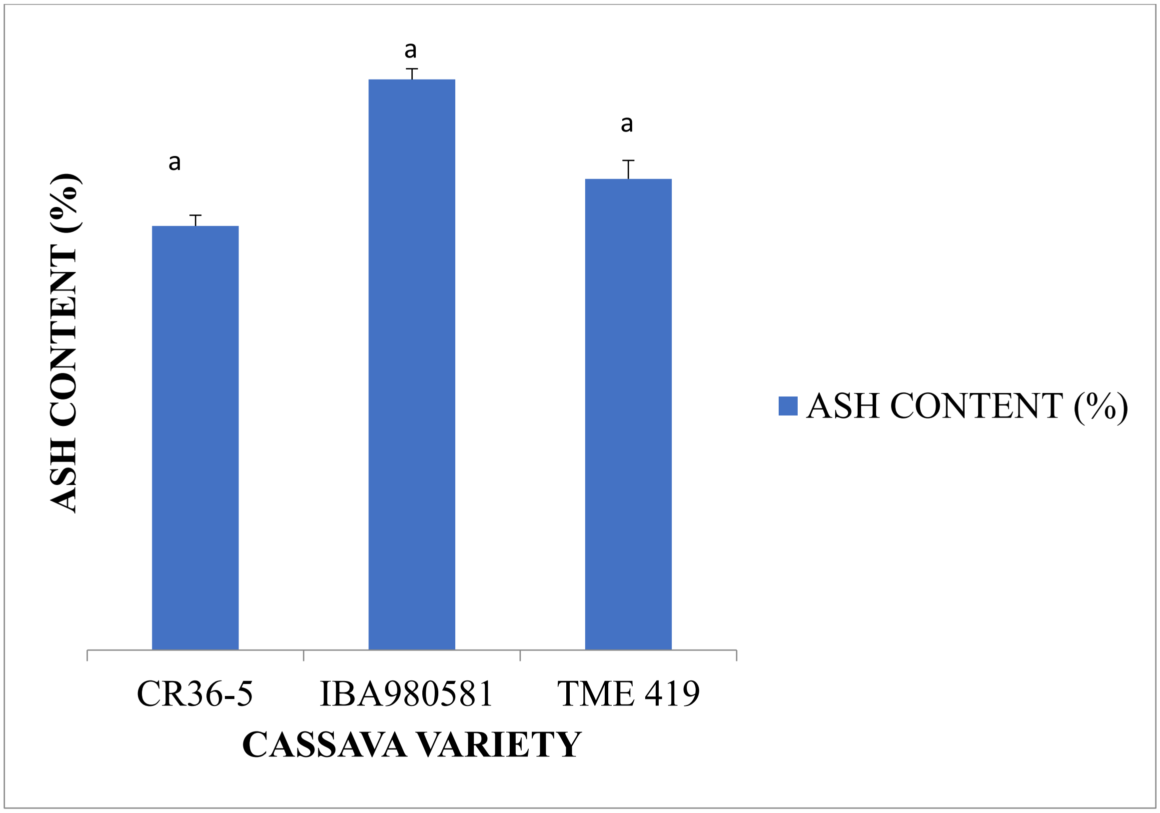

Figure 3: Comparative analysis of Ash content of Leaves of TME419, IBA980581 and CR36-5 cassava varieties.

Values are expressed as mean ± SEM (n = 3). Bars with different superscripts (a, b, c) are significantly different at (p<0.05).

The findings of this study also provided details that CR36-5 had the highest crude fiber content, followed by IBA980581 which was still significantly higher than TME 419 in crude fiber.

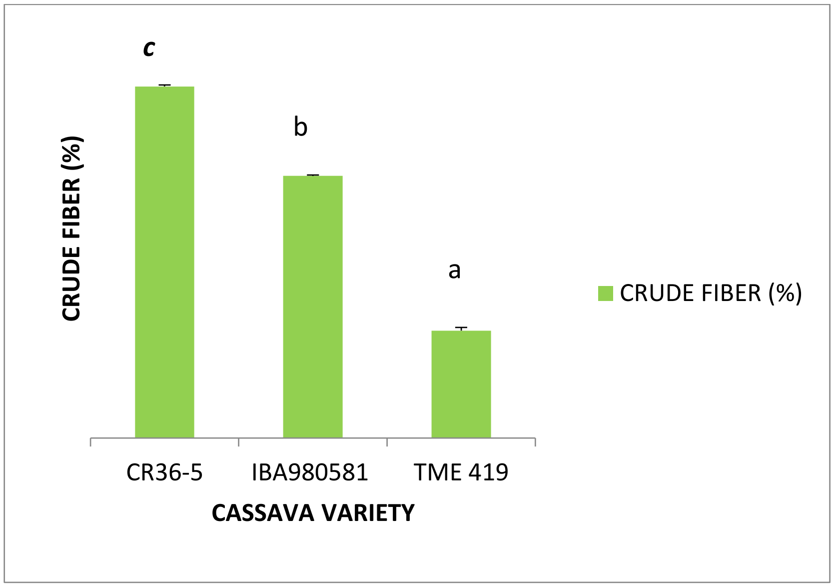

Figure 4: Comparative analysis of crude fiber in the leaves of TME 419, IBA980581, and CR36-5 cassava varieties.

Values are expressed as mean ± SEM (n = 3). Bars with different superscripts (a, b, c) are significantly different at P < 0.05.

An insight into the result of this present analysis showed that CR36-5 had the highest protein content. Though the value of the protein content in BA980581 seems greater than TME 419, statistical analysis revealed that CR36-5 is significantly different from the two other cassava leaf varieties in protein content while no significant difference was found between BA980581 and TME 419 varieties.

Confluence Journal of Pure and Applied Sciences, Volume 5 Issue 1, March, 2026 Pp 70-90

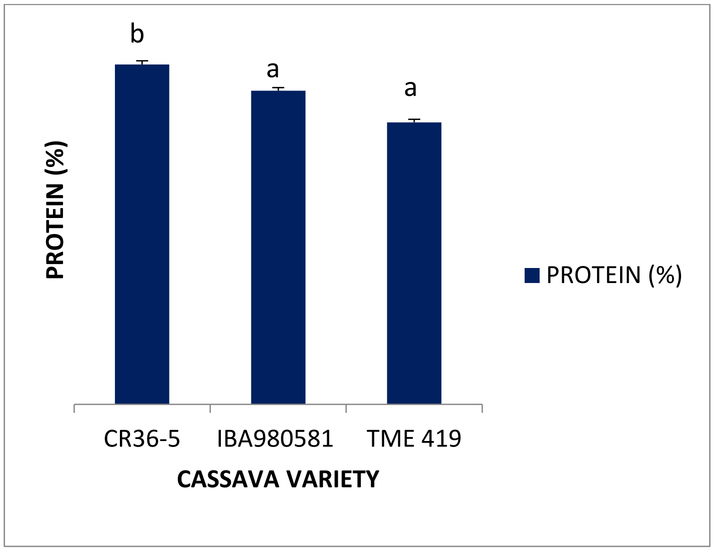

Figure 5: Comparative analysis of Protein content of Leaves of TME419, IBA980581 and CR36-5 cassava varieties.
Values are expressed as mean ± SEM (n = 3). Bars with different superscripts (a, b, c) are significantly different at ($p<0.05$).

The result of this present analysis also revealed that CR36-5 leaf was significantly higher in lipid content, than IBA980581 which was again significantly higher in protein content than TME419.

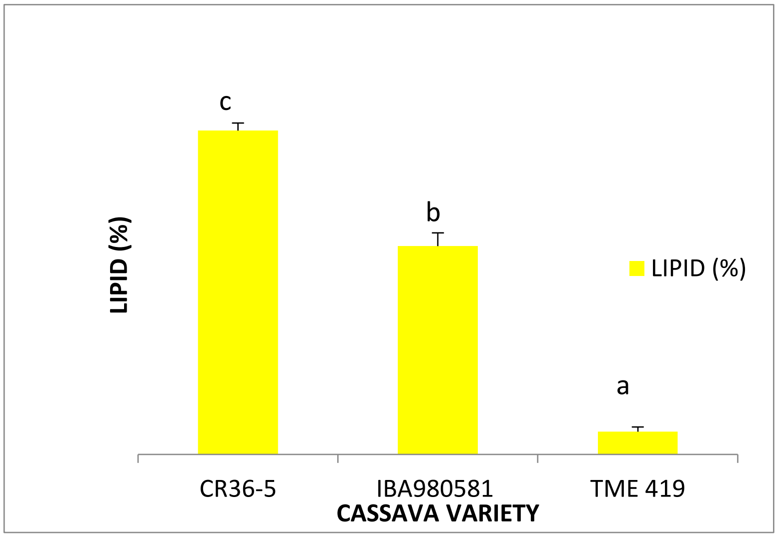

Figure 6: Comparative analysis of Lipid content of Leaves of TME419, IBA980581 and CR36-5 cassava varieties.

Values are expressed as mean ± SEM (n = 3). Bars with different superscripts (a, b, c) are significantly different at (p<0.05).

The result of the present research revealed that carbohydrate content was significantly higher in TME 419 and significantly lower in both IBA980581 and CR36-5 leaves.

Confluence Journal of Pure and Applied Sciences, Volume 5 Issue 1, March, 2026 Pp 70-90

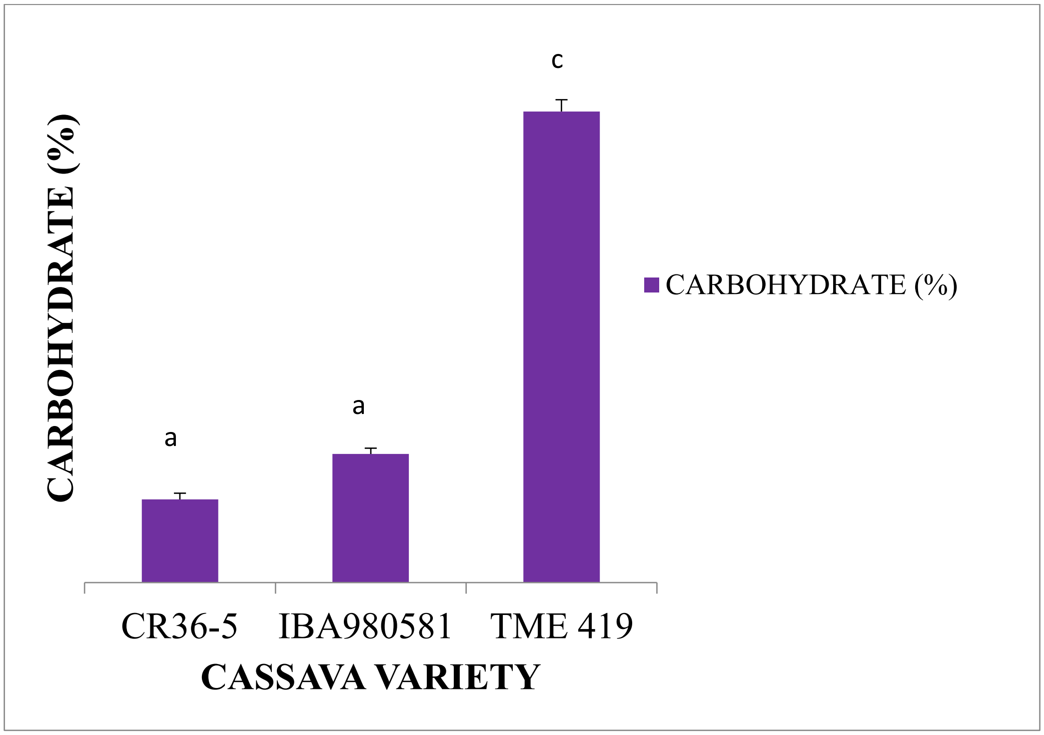

Figure 7: Graph of comparative analysis of Carbohydrate content of Leaves of TME419, IBA980581 and CR36-5 cassava varieties.

Values are expressed as mean ± SEM (n = 3). Bars with different superscripts (a, b, c) are significantly different at ($p<0.05$).

DISCUSSION

The results of this study highlight significant variations in the proximate nutritional composition among the leaves of the three cassava varieties: TME419, IBA980581, and CR36-5. These differences underscore the influence of genetic factors on nutritional profiles, which can inform breeding programs aimed at enhancing the nutritional value of cassava leaves as a food source, particularly in regions where they serve as a staple vegetable or feed supplement. Overall, CR36-5 emerged as the variety with superior levels of protein, crude fiber, and lipids, albeit with lower moisture and carbohydrate content, aligning with its potential for higher nutritional density on a dry matter basis. In contrast, TME419 exhibited the highest carbohydrate content but lower levels of protein, fiber, and lipids, while IBA980581 showed intermediate traits with elevated moisture and ash. These patterns are consistent with the findings of Latif and Muller

(2015), indicating that cassava leaf composition varies by variety, environmental conditions, and maturity stage.

Moisture content in cassava leaves is a critical factor affecting shelf life, processing suitability, and overall nutrient concentration. In the present study, IBA980581 and TME419 displayed significantly higher moisture levels compared to CR36-5, with no significant difference between the former two varieties. This finding suggests that CR36-5 leaves may have better storage potential due to reduced susceptibility to microbial spoilage. Comparative analyses from recent studies corroborate this variability; for instance, an investigation of 12 Nigerian cassava varieties, including IBA980581 (8.89 ± 0.05%) and TMEB419 (9.78 ± 0.01%, likely synonymous with TME419), by Adeyeye and Aye (2020), revealed moisture contents ranging from 8.09% to 10.90%, with significant differences attributed to genetic factors. This present study found that IBA980581 and TME419 had similar moisture content (no significant difference), both significantly higher than CR36-5, which had the lowest moisture content. CR36-5 could be prioritized for dried leaf products to minimize post-harvest losses

The lower moisture in CR36-5 suggests it might have a relatively higher dry matter content per unit fresh leaf, possibly indicating better storage stability or reduced susceptibility to spoilage or microbial activity post-harvest. The variation in moisture could be influenced by genetic differences in leaf structure, cuticle thickness, stomatal regulation, or water content in cells. This is in tandem with Jacob et al. (2019) who carried out proximate analysis on several cassava leaves in Nigeria and reported that moisture (or inversely, dry matter) of cassava leaves varies depending on variety, maturity stage, and environmental conditions

There was no statistically significant difference in the ash content between the three cassava leaf varieties used in this study: TME419, IBA980581, and CR36-5. According to the specified agronomic and environmental circumstances, this implies that these genotypes have a comparatively consistent inorganic nutrient potential. Such constancy could be an indication of strict physiological control over mineral accumulation, which may be less genotype-influenced than characteristics like fiber or protein. This result is not consistent with a number of published research. For example, Koubala et al. (2019) found that the ash content varied by genotype, with

IBA980581 having an ash content of 8.82 ± 0.07% and TME419 having an ash content of 8.13 ± 0.23%. The ash level ranged from 6.88 ± 0.42% to 9.64 ± 0.08% across cassava varieties. Similar findings were made by Peprah et al. (2020), who noted notable variations in the amount of ash in provitamin A-rich cassava cultivated in Ghana and attributed the variance to both genetic and environmental factors.

According to a more comprehensive assessment Bayata, (2019), the ash content of cassava leaves is often higher than that of legumes and the majority of leafy vegetables, with the exception of soybeans. Previous studies underlined that cultivar and plant age have a big impact on mineral accumulation. Furthermore, ash levels in processed cassava leaves ranged from 7.8% to 14.7%, depending on fermentation techniques, according to a study by Moraes (2021), highlighting how post-harvest processing can increase mineral content above varietal baselines. Uniform growth conditions may be the cause of the current study's lack of variance, as they may obscure genotypic differences. However, the three types' comparable ash values suggest that each might make a significant contribution to dietary mineral consumption. The current findings somewhat contradict literature that emphasizes genetic and processing factors, even if they demonstrate mineral stability across genotypes. The dynamics of the mineral concentration in cassava leaves may be better understood in future research that takes into account various settings and post-harvest treatments.

The present study revealed a clear hierarchy in crude fiber content among cassava leaf varieties: CR36-5 > IBA980581 > TME419. The significantly higher fiber in CR36-5 suggests a greater proportion of cell wall constituents such as cellulose, hemicellulose, and lignin. These components not only influence digestibility but is often inversely related to carbohydrate availability which contribute to structural integrity and potential drought or stress tolerance. This pattern is consistent with the findings of Jacob et al. (2019), which reported crude fiber values ranging from 4.57 ± 0.06% to 13.33 ± 0.31% across cassava genotypes, with TME419 at 9.93 ± 0.05% and IBA980581 at 7.13 ± 0.23%, indicating significant varietal differences. Although TME419 in that study showed higher fiber than IBA980581, the current results suggest that environmental conditions and genotype interactions may shift fiber profiles.

A broader review by Peprah et al. (2020) emphasized cassava leaves as a rich source of dietary fiber, with values ranging from 0.5 to 10 g/100g fresh weight, depending on cultivar and maturity stage. This supports the current observation that all three varieties possess meaningful fiber levels, though CR36-5 stands out for potential gut health applications.

Processing methods also play a crucial role. A study on dried cassava leaves carried out by Kulakow (2022), reported fiber contents between 12.9% and 17.7%, with fermentation reducing fiber to improve palatability and digestibility, especially in animal feed formulations. This suggests that while CR36-5 may be ideal for fiber-rich diets, its use in feed or human consumption may require processing adjustments to balance nutritional benefits with energy availability. The intermediate fiber level in IBA980581 may represent a nutritional compromise, offering adequate fiber without compromising digestibility. In contrast, TME419's lower fiber content implies a softer leaf texture, potentially more suitable for direct consumption or formulations requiring higher digestibility. These findings align with the report of Oreshina et al. (2019) that confirmed genotypic variation in crude fiber content among cassava varieties, reinforcing the role of genetic and environmental factors in shaping nutritional profiles.

Protein content, a critical nutritional parameter in cassava leaves, was found to be significantly higher in CR36-5 compared to IBA980581 and TME419, with no statistical difference between the latter two. This positions CR36-5 as a promising candidate for protein-enriched diets, particularly in regions facing nutritional deficiencies. The elevated protein levels in CR36-5 may reflect genetic traits favoring nitrogen assimilation or leaf biomass composition, making it suitable for both human consumption and animal feed applications. This result is consistent with the report of Adeyeye and Aye (2020) which highlights substantial variability in cassava leaf protein content.

The lack of significant difference between IBA980581 and TME419 suggests that these genotypes may share similar physiological limits for protein accumulation under the tested conditions. However, their lower values compared to CR36-5 imply less suitability for high-protein dietary formulations. This observation aligns with findings of Silva et al. (2024) which recognized cassava leaves as protein-rich among leafy biomass, though noted their deficiency in essential amino acids, necessitating complementary sources in diet planning. CR36-5 stands out as a nutritionally superior genotype for protein content, with potential applications in nutritional rehabilitation, feed formulation, and functional food development. Its performance underscores the importance of genotype selection and post-harvest processing in maximizing the nutritional value of cassava leaves.

The present study revealed a clear and statistically significant trend in lipid content among cassava leaf varieties: CR36-5 > IBA980581 > TME419. This hierarchy suggests that CR36-5 possesses a greater capacity for lipid accumulation, which may be linked to genotype-specific metabolic pathways or leaf structural traits. Although cassava leaves are generally low in lipids compared to seeds or tubers, even modest increases can enhance their energy density and nutritional value, especially in feed applications.

These findings are consistent with earlier research. A varietal analysis carried out by Koubala, et al. (2019) reported lipid contents ranging from $3.16 \pm 0.05\%$ to $8.00 \pm 0.02\%$, with IBA980581 at $5.43 \pm 0.04\%$ and TME419 at $3.45 \pm 0.05\%$, closely mirroring the current study's rankings. Previous studies have also noted cassava leaf lipid levels between 0.2–2.9 g/100g fresh weight, or 6.8–7.9% in dried samples, reinforcing the notion that while cassava leaves are not lipid-rich, they do contain more fat than the tubers themselves.

The current results also align with Olugbemi et al. (2018), who found that cassava leaves contain somewhat more lipids than tubers, though still relatively low overall. This supports the idea that leaf-based cassava products, especially from high-lipid genotypes, could serve as supplementary energy sources in both human and animal diets. However, CR36-5's superior lipid content positions it as a valuable genotype for nutritional applications requiring higher energy yield. Its performance underscores the importance of genotypic selection and processing strategies in optimizing cassava leaf utility.

The present study found that TME419 had significantly higher carbohydrate content compared to CR36-5 and IBA980581, which did not differ significantly from each other. This suggests that TME419 may allocate more biomass to soluble sugars, non-fiber carbohydrates, or residual starch, enhancing its role as an energy-rich genotype. In contrast, the lower carbohydrate levels in CR36-5 and IBA980581 likely reflect a nutrient trade-off, where increased protein, fiber, and lipid content reduces the proportion of carbohydrates. This pattern is consistent with the findings of Koubala, et al., (2019) who reported carbohydrate contents of 51.15 ± 0.01% for IBA980581 and 49.03 ± 0.02% for TMEB419 on a dry matter basis. These values support the current observation of TME419's carbohydrate dominance.

In Sierra Leone, Jalloh et al. (2025) recently carried out their research and their result showed that carbohydrate levels ranging from 10.26% to 16.84% (dry basis), with significant variation across districts, further emphasizing the influence of location and agroecological factors on nutrient composition. Moreover, a study by Santanoo et al. (2024) highlighted that carbohydrate partitioning among cassava genotypes is influenced by photosynthetic performance and drought stress, with energy-focused varieties like TME419 maintaining higher sugar reserves under stress.

The inverse relationship between carbohydrate and other macronutrients is well-documented. According to Boukhers, et al. (2020), cassava leaf carbohydrate content tends to decrease as protein and fiber increase, reflecting a physiological balance in nutrient allocation. This trade-off is particularly evident in CR36-5, which showed elevated protein and fiber but reduced carbohydrate levels. Processing also affects carbohydrate content. Fermentation, commonly used in aquaculture feed preparation, reduces carbohydrates through microbial breakdown, improving digestibility and nutrient availability. This suggests that while TME419 may be ideal for energy-dense formulations, CR36-5 could benefit from processing to optimize its nutritional profile.

CONCLUSION

In conclusion, this research revealed significant variations in the nutritional profiles of the leaves of the three different cassava varieties, highlighting their potential for targeted applications in human nutrition and animal feed. The findings demonstrates that CR36-5 leaves are particularly rich in protein, fiber, and lipids, positioning them as a valuable resource for enhancing dietary nutrition. TME419 leaves, with their high carbohydrate content, offer a complementary nutritional profile, while IBA980581 strikes a balanced composition, bridging the nutritional attributes of the other two varieties. These insights underscore the importance of varietal selection in optimizing the nutritional benefits of cassava leaves, a critical dietary resource in many regions. By informing agricultural practices and food security strategies, this study paves the way for more effective utilization of cassava leaves to address nutritional needs. Future research should focus on investigating anti-nutritional factors and optimizing processing techniques to further enhance the nutritional value and safety of these leaves, ensuring their broader applicability in sustainable food systems.

AUTHOR'S CONTRIBUTION

Conceptualization: Ataguba Ele-Ojo. Data curation: Ataguba Ele-Ojo/ Okpe, John Mathias Formal analysis: Ataguba Ele-Ojo. Funding acquisition: Individual. Investigation: Ataguba Ele-Ojo / Atebije Christain. Methodology:Ataguba Ele-Ojo / Shaibu Victoria Nemile. Project administration: Ataguba Ele-Ojo / Atebije Christain/Umar Odekina Menyaga. Resources: All Authors. Software: Okpe, John Mathias. Supervision: Ataguba Ele-Ojo. Validation: Ataguba Ele-Ojo

CONFLICT OF INTEREST

The authors declare they have no competing interest.

ACKNOWLEDGEMENTS

The authors are thankful to Prof. Atawodi S. E. (Department of Biochemistry), Federal University Lokoja for his mentorship and provision of a well encouraging academic environment, Prof. Amanabo, Musa of the IBB University Lapai for the contribution of his wealth of knowledge and experience through mentorship in the course of this work, the Technologist and all staff of the Department of Biochemistry Laboratory, Federal University Lokoja as well as Mr. Sumaila Onudoga Mohammed, President of the Kogi State Network of Cassava Seed Entrepreneurs for their availability and support in the course of this research adventure.

REFERENCES

Achidi, A., Olufunmikea, A., Bussiemaziya, D. & Mpoko, B. (2005). The effects of processing on the nutrient content of cassava (manihotesculentacrantz) leaves. 317(52): 165.

Adetunji, C. O., Enitan, S. O., Ibitoye, B. O. & Ojo, E. F. (2023). Correlate the cyanogenic potential and dry matter content of cassava roots and leaves: Genetic gain assessment trials in three agro-ecological zones of Nigeria. *Scientific Reports*. 13(1): 15408.

Adeyeye, S. A. O. & Aye, P. A. (2020). Proximate composition and mineral contents of cassava leaves from selected varieties in Nigeria. *Journal of Food Science and Nutrition Research*, 3(2): 157-166.

Akinwade, A. A., Oyelola, O. O., Ogunlade, J. T. & Adeyemo, A. A. (2019). Proximate composition of different variety of cassava leaves. *International Journal of Current Research*, 11(9): 12022-12026.

Alamu, E. O., Dixon, A., Eyinla, T. E. & Maziya-Dixon, B. (2022). Characterization of macro and micro-minerals in cassava leaves from genotypes planted in three different agroecological locations in Nigeria. Heliyon, 8(11): e11618. https://doi.org/10.1016/j.heliyon.2022.e11618

Alamu, E. O., Prisca, C., Olaniyan, B., Omosebi, M. O., Adegunwa, M. O., Chikoye, D. & Maziya-Dixon, B. (2021). Evaluation of nutritional properties, and consumer preferences of legume-fortified cassava leaves for low-income households in Zambia. Cogent Food & Agriculture, 7(1): 1888938 https://doi.org/10.1080/23311932.2021.1885796.

AOAC international 920.39 (2019-2023). Official methods of analysis of AOAC International (21st edition). AOAC international

Bayata, A. (2019). Review on Nutritional Value of Cassava for Use as a Staple Food. *Science Journal of Analytical Chemistry*, 7(4): 83. https://doi.org/10.11648/j.sjac.20190704.12

Boukhers, I., Boudard, F., Morel, S., Servent, A., Portet K., Guzman C., Vitou M., Kongolo J., Michel A. & Poucheret P. (2020). Nutrition, Healthcare Benefits and Phytochemical Properties of Cassava (*Manihot esculenta)* Leaves Sourced from Three Countries (Reunion, Guinea, and Costa Rica). *Foods*. 11(14): 2027. doi: 10.3390/foods11142027. DOI: 10.12691/ajfst-3-2-3.

Boukhers, I., Boudard, F., Morel, S., Servent, A., Portet, K., Guzman, C., Vitou, M., Kongolo, J., Michel, A. & Poucheret, P. (2022). Nutrition, healthcare benefits and phytochemical properties of cassava (Manihot esculenta) leaves sourced from three countries (Reunion, Guinea, and Costa Rica). Foods, 11(14): 2027. https://doi.org/10.3390/foods11142027

Boyer, G. A., Hassan, A., Yerima, B. I. & Markus, M. (2020). Crude protein determination using micro-kjeldahl method. *Chemistry Research journal,* 5(2): 157 – 161.

Edet, I. V., Akpomie, T. M., Augustine, A. U., Samoh, T. F., Ekam, E. & Nzegbuna, D. D. (2023). Comparative Analysis on the Proximate Composition of Processed Cassava Products Obtained from January to March, 2023 in Lafia Town, Nigeria. *Chemical Science International Journal,* 32(4): 50–63. https://doi.org/10.9734/CSJI/2023/v32i4854

Idris, S. B., Shamsudin, R., Mohd Nor, M. Z., Mokhtar, M. N. & Abd Ghani, S. S. (2021). Proximate Composition of Different Parts of White Cassava (Manihot esculenta Crantz) Plant as a Ruminant Feed. *Advances in Agricultural and Food Research Journal*, 2(1): 181.

International Organization for Standardization (2022). Food and feed products – General guidelines for determination of carbohydrates by the Kjeldahl method. ISO 1871: 2022, 3-10.

International Organization for Standardization. (2020). Agricultural food products, Determination of crude fiber content. General method. Geneva, Switzerland: (ISO 5498:2020) 4 – 6.

International Organization for Standardization. (2021). Oilseeds: Determination of oil content. Extraction method. Geneva, Switzerland: (ISO 659:2021) 6 – 8.

International Organization for Standardization. (2023). Cereals, pulses and by-products, Determination of ash content. Geneva, Switzerland: (ISO 2171:2023) 7 - 8

International Organization for Standardization. (2023). Meat and meat products Determination of nitrogen content — Kjeldahl method. Geneva, Switzerland: (ISO 937:2023) 3 - 4

Jacob, O. P., Egwari, L. O. & Bilewu, Y. (2019). Proximate analysis and SDS-PAGE protein profiling of cassava leaves: utilization as leafy vegetable in Nigeria. *MOJ Ecology & Environmental Sciences.* 4(1): 1-5. DOI: 10.15406/mojes.2019.04.00125

Jalloh, M. A., Dukuray, S. A. & Amara, M. (2025). Nutritional values of cassava leave in three districts, Kenema, Kailahun, and Bo, Sierra Leone. *Prime Open Access Journal of Agricultural Research (POAJAR),* 9(1): 1–13.

Jin, S., Zhang, L. & Xu, J. (2024). Evaluation of nutritional quality of improved cassava varieties. *Plant Foods for Human Nutrition*, 79(1): 55-63. https://doi.org/10.1007/s11130-023-00994-3

Kang, H., Li, J. & Zhang, W. (2024). Proximate composition and amino acid profile of cassava leaves: A comparative study. *Nutritional Sciences,* 35(2): 89-101. https://doi.org/10.1016/j.nutres.2023.12.007

Koubala, B. B., Alphonse L., Harouna M., Habiba K. & Elias N. N. (2015). *American Journal of Food Science and Technology*, 3 (2): 40-4

Kulakow, P. (2022). Genetic variability and genotype by environment interaction of two major cassava processed products in multi-environments. *Frontiers in Plant Science.* 974795 (13): 1–17. https://doi.org/10.3389/FPLS.2022.974795

Latif, S. & Muller, J. (2015). Potential of Cassava Leaves in Human Nutrition. *Trends in Food Science & Technology*, 44: 147-158. https://doi.org/10.1016/j.tifs.2015.04.006.

Moraes, J., Campos, A. P. R., Araujo, A. L., Lopes, A. S. & Pena, R. S. (2021). Minimally processed cassava leaves: effect of packaging on the microbiological and physical-chemical standards. *Scientia Plena*, 17(5): 6 – 12. https://doi.org/10.14808/sci.plena.2021.051501

Oboh, G., Afolayan, A. J. & Ademosun, A. A. (2015). Traditional methods of detoxifying cassava in Nigeria: A comparative study of different techniques. *Food and Chemical Toxicology,* 83: 71-76.

Olugbemi, T. S., Schwietzke, T. & Webb, R. (2018). Cassava: Nutrient composition and nutritive value in poultry diets. *Frontiers in Nutrition*. PMC. 39(4): 20 -24.

Oreshina, A. T., Oluwole, T. O. & Thomas, B. T. (2019). Proximate analysis and SDS-PAGE protein profiling of cassava leaves utilization as leafy vegetable in Nigeria. *MOJ Ecology & Environmental Sciences.*4(1): 1–5.

Peprah, B. et al. Peprah, B. B., Parkes, E. Y., Harrison, D. A., van Biljon, A., Gumede, N., Gracen, V., Asante, I., Danquah, E., Adjei, P. Y., Labuschagne, M. T., Kulakow, P. & Rabbi, I. Y. (2020). Proximate Composition, Cyanide Content, and Carotenoid Retention after Boiling of Provitamin A-Rich Cassava. *MDPI Foods*, 9(12): 1800.

Santanoo, S., Santanoo, S., Oon-ruan, A., Girdthai, G., Phitaktansakul, T., Amkha, S., Phithak, W., Sookphan, W. & Pang-nga, K. (2024). Photosynthetic Performance, Carbohydrate Partitioning, Growth, and Yield among Cassava Genotypes. *MDPI Plants*, 13(15): 2049.

Silva, K. A. d., Machado, B. A. S. & Miranda, M. d. R. (2024). Cassava leaves as an alternative protein source: Effect of alkaline parameters and precipitation conditions on protein extraction and recovery. ScienceDirect.com, 187: 115712.

Terefe, T., Otondi, E. A. & Terefe, O. (2022). Effectiveness of Levilactobacillus brevis fermentation on detoxification of cyanogenic compounds and enhancing protein quality in cassava leaves (Manihot esculenta Crantz). *Future Foods*, 6: 100094