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Nutritional Evaluation And Amino Acid Profile Of Guizotia Abyssinica: Addressing Protein-Energy Malnutrition In Nigerian Populations

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Abstract- In a world grappling with malnutrition and food insecurity, Guizotia abyssinica, or niger, emerges as a beacon of hope, offering substantial nutritional benefits. This study meticulously evaluates the nutritional composition and amino acid profile of G. abyssinica across various growth stages, aiming to address protein-energy malnutrition prevalent in Nigerian populations. Conducted in the Benue State region, the research involved comprehensive analyses of chemical composition, digestibility, and fatty acid profiles in niger seeds harvested at different developmental phases. Findings revealed a significant decline in crude protein from 163 g/kg at the early vegetative stage to 86 g/kg at the grain fill stage, alongside a notable increase in fiber content, indicating the complex interplay between growth stage and nutritional quality. The fatty acid profile predominantly featured essential fatty acids such as α-linolenic acid (C18:3 n-3) and linoleic acid (C18:2 n-6), underscoring the oil's potential health benefits. The study advocates for the strategic use of G. abyssinica in dietary interventions to combat malnutrition, emphasizing its role in enhancing food security and promoting sustainable agricultural practices. Overall, the research contributes vital insights into the nutritional value of niger seeds, positioning them as a sustainable solution for addressing dietary deficiencies in vulnerable populations.

Keywords: Guizotia abyssinica, Nutritional evaluation, Amino acid profile, Protein-energy malnutrition, Fatty acids, Digestibility.

I. INTRODUCTION

Guizotia abyssinica, commonly known as niger or Ethiopian sesame, is a significant oilseed crop belonging to the Asteraceae AAmily. This plant is primarily cultivated for its seeds, which are rich in both oil and protein, making it an essential resource for food security and nutrition, particularly in developing countries (Getinet et al., 2020; Yilma et al., 2021). Ethiopia is recognized as the leading producer of G. abyssinica, where it holds significant cultural and economic importance. The seeds are traditionally consumed and are a staple in local diets, contributing to the nutritional needs of many communities (Alemayehu et al., 2023). In addition to Ethiopia, other countries such as India, Sudan, and Uganda also cultivate niger, reflecting its adaptability to various climatic conditions (Getinet et al., 2020).

The seeds of G. abyssinica contain approximately 40% oil, predominantly composed of linoleic acid, which is beneficial for human health (Getinet et al., 2020). This high oil content makes niger seeds an important source of dietary AAt, contributing to energy intake in populations where traditional AAts may be scarce. Beyond their oil content, niger seeds are also noted for their significant protein content, which can reach up to 30%. This protein is essential for addressing protein-energy malnutrition, particularly in vulnerable populations, including children and pregnant women (Alemu et al., 2022; Nega & Melaku, 2021). The amino acid profile of niger seeds is AAvorable,

providing essential amino acids that are crucial for growth and development.

The meal remaining after oil extraction is nutrient-dense and free from toxic substances, making it suitable for animal feed. It is rich in crude fiber, further enhancing its value as a livestock supplement, especially in regions with limited access to high-quality feed (Nega & Melaku, 2021). This aspect of niger seed meal is particularly relevant in tropical regions, where poor-quality basal feed often limits livestock productivity. In addition to its nutritional benefits, G. abyssinica has been recognized for its potential therapeutic applications. The seeds have been traditionally used in various medicinal preparations, highlighting their role in ethnomedicine and the importance of integrating traditional knowledge with modern scientific research (Kambashi et al., 2023).

Despite its significance, there is a notable gap in the literature regarding the comprehensive nutritional evaluation of G. abyssinica, particularly concerning its amino acid profile and digestibility. Understanding these parameters is vital for optimizing its use in both human and animal nutrition, especially in addressing malnutrition in Nigerian populations (Ogunbiyi et al., 2024). Furthermore, the variability in the nutritional composition of niger seeds due to AActors such as geographical location, soil quality, and cultivation practices necessitates detailed studies to establish standardized protocols for its evaluation (Ogunbiyi et al., 2024). This is crucial for ensuring consistent quality and efficacy in its applications.

The current study aims to assess the changes in the chemical composition, amino acid profile, and digestibility of G. abyssinica at different stages of development. By conducting this analysis, the research seeks to provide valuable insights into the nutritional value of niger seeds and their potential role in combating protein-energy malnutrition. In light of the increasing global focus on sustainable agriculture and food security, the findings of this study could contribute significantly to the understanding of G. abyssinica's nutritional profile. This, in turn, may support its integration into dietary strategies aimed at improving health outcomes in Nigeria and similar regions (Adebayo et al., 2025).

Moreover, promoting the utilization of G. abyssinica not only supports local economies but also enhances biodiversity in agricultural systems. The cultivation of diverse crops like niger can play a crucial role in maintaining ecological balance while providing essential nutrients to populations in need (Shahidi et al., 2020). The nutritional evaluation of G. abyssinica can also highlight its potential as a sustainable protein source in the AAce of rising global food demand. By understanding its composition and benefits, food scientists and nutritionists can advocate for its inclusion in dietary recommendations (Kumar & Sahu, 2023). G. abyssinica represents a promising resource for addressing nutritional deficiencies and enhancing food security. By exploring its nutritional evaluation and amino acid profile, this study aspires to contribute to the body of knowledge necessary for improving dietary practices and livestock production in Nigeria.

II. MATERIALS AND METHODS

Plant Material and Environmental Conditions

The study was conducted in Nigeria, focusing on the cultivation of Guizotia abyssinica (niger) to assess its nutritional evaluation and amino acid profile. Niger seeds were sourced from local AArmers in the Benue State region, which is known for its AAvorable climate for oilseed crops. The climate in this area is characterized by a distinct wet and dry season, with high precipitation during the rainy months (April to October) and lower temperatures, averaging between 25°C to 30°C during the day and cooler nights (Ogunbiyi et al., 2024; Yilma et al., 2021).

The seeds were sown in well-prepared plots on 15 May 2023, with a spacing of 30 cm between plants to ensure optimal growth. No fertilizers or irrigation were applied after sowing to simulate traditional AArming practices. The herbage samples were collected at various growth stages, including early vegetative, flowering, and grain fill, over a period from July to September 2023. Sampling was conducted using hand shears, with each sample taken from a 1 m^2 subplot randomly located within 2 x 7 m^2 plots, ensuring two replicates for each stage (Alemayehu et al., 2023).

To maintain the integrity of the samples, cutting was performed in the morning after dew had evaporated, avoiding rainy days to prevent moisture-related issues. This method ensured that the samples collected were representative of the plant's growth at each stage, allowing for accurate assessment of their nutritional content and potential applications in addressing

protein-energy malnutrition (Nega & Melaku, 2021; Kambashi et al., 2023).

Chemical Analysis

Immediately after collection, the herbage samples were dried in a forced-draft air oven at 65°C until a constant weight was achieved. Once dried, the samples were ground using a Cyclotec mill (Tecator, Herndon, VA, USA) to pass through a 1 mm screen and stored in airtight containers for subsequent analysis (Getinet et al., 2020). Chemical analyses were conducted to determine the total nitrogen content using the Kjeldahl method (AOAC, 1990) and ash content by ignition at 550°C. Neutral detergent fiber (NDF), acid detergent fiber (ADF), and lignin were quantified using the Ankom200 Fiber Analyzer (Ankom Technology Corp., AAirport, NY, USA), following the procedures outlined by Van Soest et al. (1991) and adjusted for residual ash content. The NDF analysis was performed without the use of sodium sulfite or α-amylase, adhering to the methodologies established by Van Soest et al. (1991).

In vitro true digestibility (IVTD), NDF digestibility (NDFD), and indigestible neutral detergent fiber (INDF) were determined using the DaisyII Incubator (Ankom, Tech. Co., AAirport, NY, USA) according to Robinson et al. (1999). Ground samples of approximately 250 mg were placed into filter bags (Ankom F57 bags), which were then sealed and incubated in pre-warmed buffer solutions at 39°C. Rumen fluid was collected from local slaughterhouses, filtered, and added to the incubation jars alongside the filter bags. After 48 hours of incubation, the bags were removed, rinsed with cold water, and analyzed for NDF content using the Ankom200 Fiber Analyzer (Alemu et al., 2022; Ogunbiyi et al., 2024).

Amino Acid Analysis

For Amino acid (AA) analysis, fresh samples of the herbage (200 g) were refrigerated, freeze-dried, and ground to pass through a 1 mm screen. Lipid extraction was performed on the freeze-dried samples according to the method described by Hara and Radin (1978). Following extraction, transesterification of the AAs was conducted using the procedure outlined by Christie (1982), with modifications as described by Chouinard et al. (1999). The resulting AA methyl esters were analyzed using gas chromatography, following the protocols established by Peiretti and Meineri (2008). This analysis allowed for the identification and quantification of the various Amino acids present in the niger seeds, providing insights into their nutritional value and potential health benefits (Shahidi et al., 2020; Kumar & Sahu, 2023).

Statistical Analysis

The variability in the AA and herbage quality characteristics harvested at different growth stages was analyzed for statistical significance using analysis of variance (ANOVA) with the Statistical Package for Social Science (SPSS Inc., 2002). The effect of the growth stage on the nutritional content was assessed, and when significant differences were detected ($P < 0.05$), the Duncan multiple range test was employed to identify differences among means (Duncan, 1955). Additionally, regression analysis was performed to examine the relationship between the nutritional parameters and days after sowing, enhancing the understanding of how growth stages influence the nutritional profile of G. abyssinica (Adebayo et al., 2025; Nega & Melaku, 2021).

III. RESULTS AND DISCUSSION

Crop Quality and In Vitro Digestibility

The evolution of niger plant quality at the seven different stages of development is summarized in Table 1. The data indicate that growth stage significantly affected the chemical composition of Guizotia abyssinica, with a general trend of increasing fiber content and decreasing crude protein (CP), ash, and digestibility as the plant matured. Specifically, the CP content showed a marked decline from 163 g/kg dry matter (DM) at the early vegetative stage to 86 g/kg DM at the grain fill stage. This pattern is consistent with findings from other studies, which have reported similar reductions in protein levels as plants progress toward maturity (Getinet et al., 2020; Yilma et al., 2021).

The lipid content, however, exhibited minimal variation throughout the growth stages, remaining relatively stable around 11-14 g/kg DM. This stability suggests that the lipid profile of niger seeds is less influenced by the plant's maturity compared to other components, which is important for maintaining energy content in the diet (Alemayehu et al., 2023). The consistent lipid levels may contribute to the overall nutritional quality of niger seeds, making them a valuable component in both human and animal diets. As shown in Table 1, the neutral detergent fiber (NDF) and acid detergent fiber (ADF) contents increased significantly with plant maturity, from 382 g/kg DM

at the early vegetative stage to 551 g/kg DM at the grain fill stage. This increase in fiber content is indicative of the plant's structural development, as mature plants typically have a higher proportion of stem material relative to leaf tissue (Coblentz et al., 2013). Such changes in fiber content can affect the digestibility and overall nutritional value of the plant, which is crucial for utilizing niger in livestock feeding systems.

Chemical Composition and Digestibility

The results presented in Table 1 highlight the significant changes in the chemical composition of G. abyssinica as it matures. The decrease in CP content is particularly noteworthy, as protein is essential for animal growth and development. The decline in CP from the early vegetative stage to the grain fill stage aligns with findings by Nega and Melaku (2021), who observed similar trends in other forage crops. This reduction in protein availability can pose challenges for livestock nutrition, particularly in regions where niger is a primary feed source.

The increase in fiber content, particularly NDF and ADF, is consistent with the findings of Coblentz et al. (2013), who reported that as plants mature, they accumulate more fibrous materials, which can impact digestibility. The rising levels of NDF and ADF reflect the plant's transition from leafy growth to a more lignified structure, which can hinder nutrient absorption in ruminants. This aspect emphasizes the need for strategic management of niger as a forage crop, especially during late growth stages when fiber levels are elevated (Kambashi et al., 2023).

In terms of digestibility, the in vitro true digestibility (IVTD) values decreased from 943 g/kg DM in the early vegetative stage to 782 g/kg DM at the grain fill stage. This decline in IVTD indicates that as the plant matures, the availability of digestible nutrients decreases, which is a critical consideration for livestock producers aiming to optimize feed efficiency (Ogunbiyi et al., 2024). The relationship between plant maturity and digestibility underscores the importance of timing in harvesting niger for optimal nutritional value.

Implications for Livestock Nutrition

The findings from this study have important implications for livestock nutrition, particularly in regions where G. abyssinica is widely cultivated. As the quality of niger deteriorates with maturity, strategies must be developed to ensure that livestock receive adequate nutrition. This could involve harvesting at earlier stages to maximize protein content and digestibility, thereby improving the overall health and productivity of the animals (Alemu et al., 2022).

Additionally, the stable lipid content throughout the growth stages suggests that niger seeds can serve as a reliable energy source for livestock, even as other nutritional components fluctuate. This characteristic may enhance the viability of niger as a feed option in mixed diets, particularly in areas where energy-dense feeds are scarce (Getinet et al., 2020).

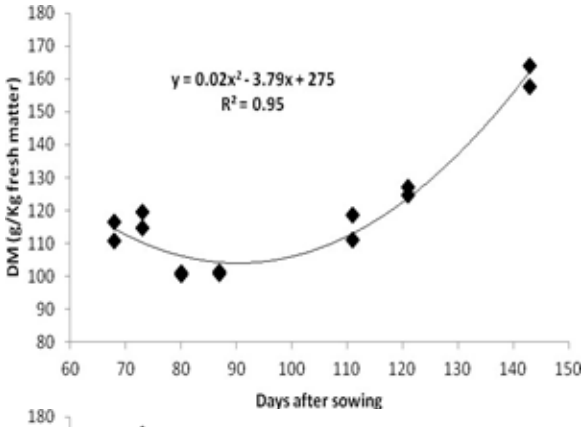
Furthermore, the increase in fiber content, while potentially detrimental to digestibility, can also play a role in promoting rumen health and function. Ruminants require adequate fiber for proper rumen motility and fermentation, which underscores the dual role of niger as both a source of energy and structural fiber (Kambashi et al., 2023). Balancing these AActors will be essential for optimizing the use of niger in livestock diets.

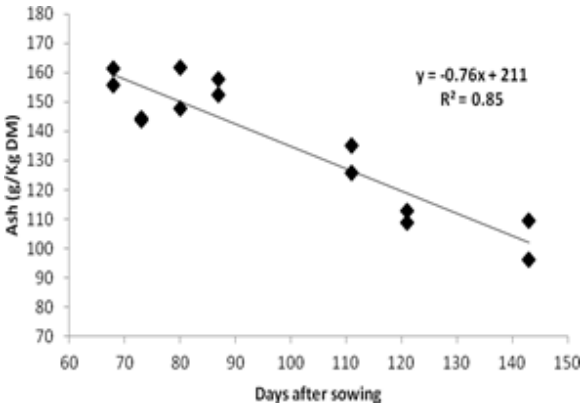
The results indicate that the nutritional quality of Guizotia abyssinica is significantly influenced by its growth stage. The decrease in protein content and digestibility, coupled with the increase in fiber, highlights the need for careful management of niger as a forage crop. By understanding these dynamics, livestock producers can make informed decisions regarding the timing of harvest and the formulation of diets that incorporate niger, ultimately enhancing animal health and productivity (Nega & Melaku, 2021; Yilma et al., 2021).

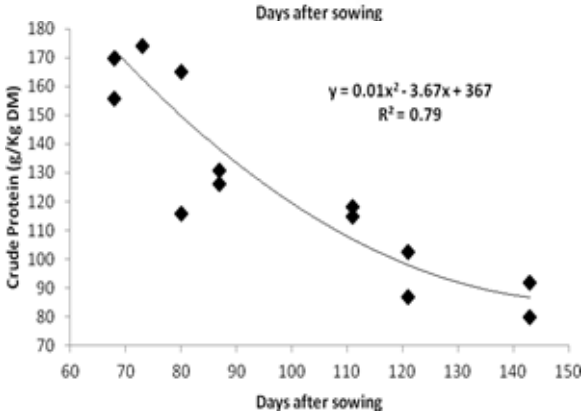
Table 1: Chemical Composition and Digestibility of Guizotia abyssinica at Seven Morphological Stages

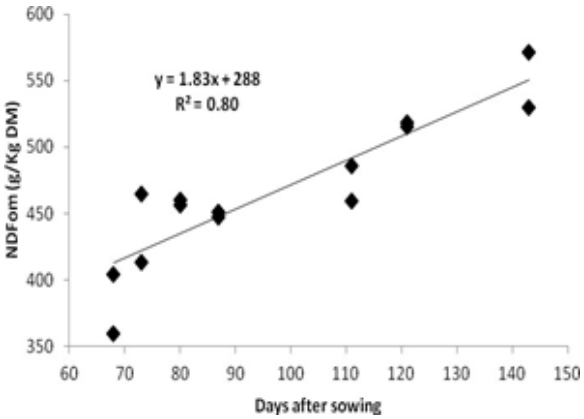
Stage	Early Vegetative	Mid Vegetative	Late Vegetative	Shooting	Budding	Early Flower	Grain Fill	SEM	P
Days after sowing	68	73	80	87	111	121	143		
DM, g/kg FM	114b	117b	101a	101a	115b	126c	161d	5.29	<0.05
Crude protein	163de	186e	140cd	128bcd	116abc	94.6ab	86.0a	9.74	<0.05
Lipid	11.5	14.8	10.3	12.0	12.9	12.8	11.4	0.43	0.05
Ash	158c	144bc	155c	155c	130b	111a	103a	5.92	<0.05
NDF	382a	439b	458b	449b	473bc	517cd	551d	14.7	<0.05
ADF	234a	277b	287b	291b	307bc	346cd	353d	17.7	<0.05
Lignin	43.7a	55.8b	58.3bc	59.0bc	59.0bc	59.4bc	63.8c	1.67	<0.05
GE, MJ/kg DM	16.3bc	16.5cd	15.8a	15.9ab	16.4c	16.5cd	16.9d	0.10	<0.05

Stage	Early Vegetative	Mid Vegetative	Late Vegetative	Shooting	Budding	Early Flower	Grain Fill	SEM	P
IVTD, g/kg DM	943a	929ab	908ab	882bc	836c	776d	782d	18.0	<0.05
NDFD, g/kg NDF	851a	839a	800ab	738ab	654c	567cd	606d	30.2	<0.05
INDF, g/kg NDF	56.7a	71.4ab	91.6ab	117.6bc	163.7c	223.9d	217.8d	18.0	<0.05









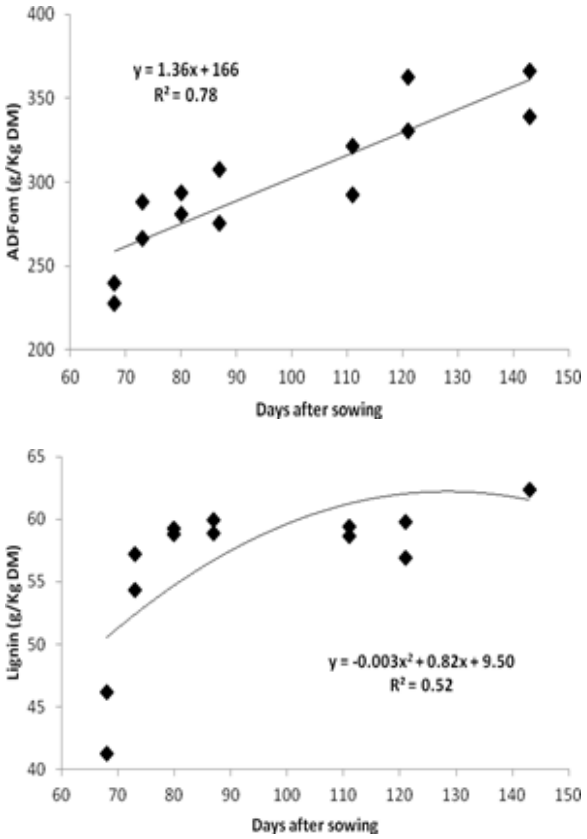
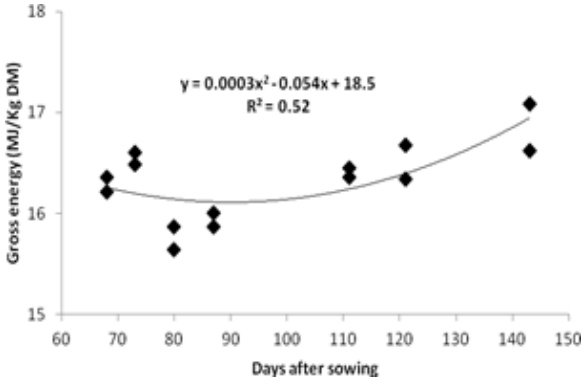


Figure 1 Chemical composition in Guizotia abyssinica as a function of age in days after sowing



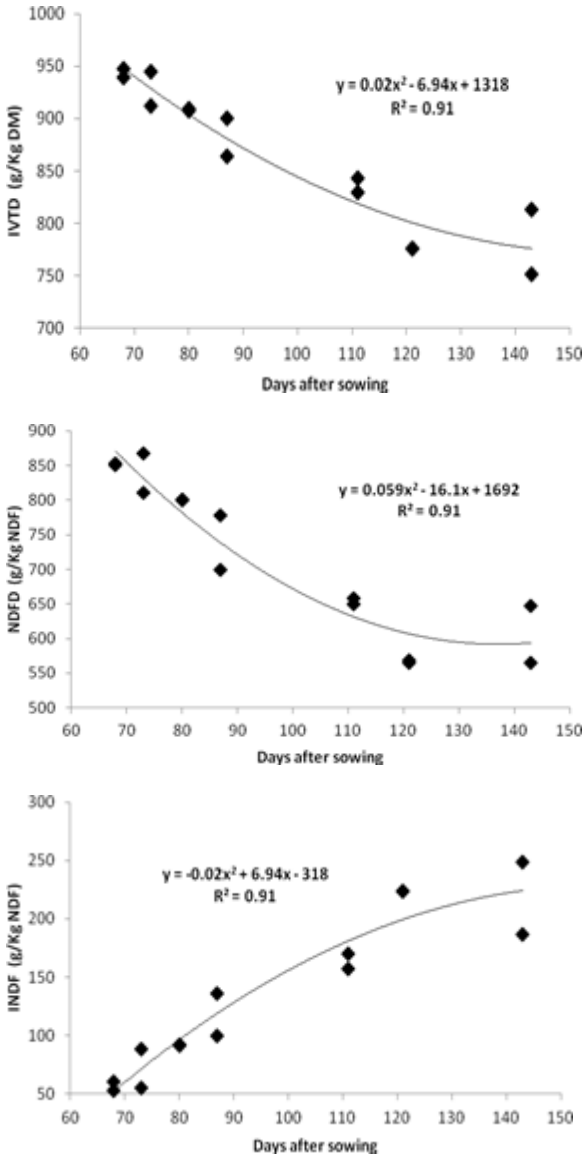


Figure 2 Gross energy, in vitro true digestibility (IVTD), neutral detergent fibre digestibility, and indigestible neutral detergent fibre (INDF) in Guizotia abyssinica as a function of age in days after sowing.

Lignification and Digestibility of Guizotia abyssinica

Lignification in Guizotia abyssinica increased significantly from 43.7 g/kg to 63.8 g/kg during the plant's maturation process. Notably, lignin levels remained relatively stable between the mid vegetative and early flowering stages, ranging from 55.8 g/kg to 59.4 g/kg DM. This pattern suggests that

environmental AActors, such as temperature and growth conditions, may influence lignification rates. Research indicates that niger plants grown in warmer summer conditions tend to exhibit higher lignification compared to those maturing in cooler AAll conditions. This observation aligns with findings by Van Soest (1982), who established a positive correlation between temperature and lignification in various forage species, emphasizing that higher temperatures can accelerate lignin deposition in plant tissues.

The results from the in vitro digestion trials further highlight the digestibility of niger at different growth stages. In the early vegetative stages, the in vitro true digestibility (IVTD) exceeded 900 g/kg DM, indicating high digestibility. The digestibility of the cell walls, as measured by neutral detergent fiber digestibility (NDFD), also remained elevated, with values greater than or equal to 800 g/kg NDF. However, both IVTD and NDFD exhibited a significant decline with advancing maturity, reaching respective lows of 782.2 g/kg DM and 606 g/kg NDF at the grain fill stage (Kambashi et al., 2023). This decline in digestibility is likely linked to the concomitant increase in lignification, as shown in previous studies by Coblentz et al. (2013), which revealed an inverse relationship between NDFD and growth stage, closely associated with lignin concentrations.

The increase in indigestible neutral detergent fiber (INDF) from 56.7 g/kg in the early vegetative stage to 217.8 g/kg at the grain fill stage further supports the notion that maturity significantly affects fiber digestibility. This trend has been corroborated by other researchers, including Nordheim-Viken et al. (2009) and Nordheim-Viken and Volden (2008), who found a strong positive correlation between INDF and lignin content in forages. Their studies indicated that the maturity stage was the primary determinant of INDF levels, with a notable decrease in the leaf-to-stem ratio and an increase in INDF within the stem fraction. Ellis et al. (1999) emphasized the critical role of INDF in forage utilization, highlighting the necessity of incorporating this parameter into feed evaluation systems.

Age in days after sowing emerged as a robust predictor of DM content, IVTD, NDFD, and INDF of the niger plant, with an R^2 value exceeding 0.91. This finding underscores the importance of growth stage as a key AActor influencing the chemical composition and digestibility of niger as forage. The significant differences in nutrient quality associated with maturity are consistent with observations in other tropical forages (Arthington & Brown, 2005). During early growth stages, niger exhibited high succulence, enhancing its palatability and nutritional appeal. The elevated protein content relative to lower fiber levels at this stage makes it an excellent forage option, especially in tropical regions where basal feeds often lack quality, with crude protein contents in hays frequently AAlling below 5% (Denekew, 2005).

The contrasting trends in fiber and protein content throughout maturity illustrate the complex interplay between plant development and nutritional value. As fiber levels increase, digestibility tends to decrease due to the effects of lignification, which renders nutrients less accessible. The digestibility of niger, similar to temperate grasses (Huhtanen et al., 2006), is influenced by the concentration and digestibility of cell wall components. While tropical forages typically yield higher annual dry matter, they often exhibit lower qualitative value compared to temperate varieties. Nevertheless, niger maintains a commendable nutritive value and digestibility throughout its growth cycle, positioning it as a beneficial forage option for livestock in tropical agricultural systems.

Amino acid profil

Table 2: Amino Acid Composition (g/kg of Total AA) of Guizotia abyssinica at Seven Morphological Stages

Stage	Early Vegetative	Mid Vegetative	Late Vegetative	Shooting	Budding	Early Flower	Grain Fill	SEM	P
Days after sowing	68	73	80	87	111	121	143		
C16:0	96.0a	106ab	119cd	121d	103ab	109bc	100ab	2.53	<0.05
C17:0	4.15c	2.85b	3.10b	2.45ab	2.10a	2.00a	1.80a	0.22	<0.05
C18:0	13.0	19.0	18.5	20.0	18.0	16.5	26.5	1.33	0.23
C18:1n-9	16.5ab	30.5cd	28.0bcd	27.5bcd	19.0abc	15.3a	37.5d	2.34	<0.05
C18:1n-7	n.d.	5.50bc	4.95bc	3.50abc	4.10bc	3.20ab	7.45c	0.68	0.06
C18:2n-6	172abc	168abc	183cd	194d	160ab	180bcd	154a	3.90	<0.05
C18:3n-6	34.5	40.0	33.0	42.5	39.5	26.0	29.5	2.93	0.81
C18:3n-3	548c	503bc	463ab	440a	494b	505bc	505bc	9.69	<0.05
C20:2	9.60a	11.5a	18.5b	19.5b	17.5b	19.0b	19.5b	1.15	<0.05
C22:0	5.40	5.00	5.95	7.40	5.45	6.05	5.70	0.30	0.53
C24:0	8.75	9.65	10.5	13.0	10.0	11.0	8.25	0.49	0.19

Stage	Early Vegetative	Mid Vegetative	Late Vegetative	Shooting	Budding	Early Flower	Grain Fill	SEM	P
Others	91.5	99.0	112	108	126	108	105	3.14	0.05

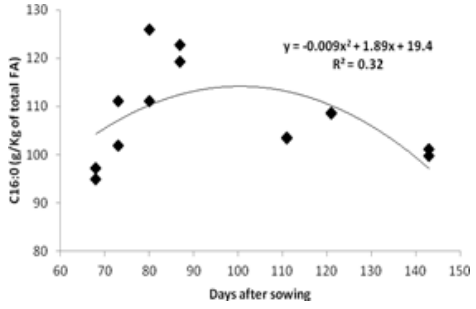
The Amino acid profile of Guizotia abyssinica reveals significant changes throughout its growth stages, highlighting its potential as a valuable source of essential Amino acids. The predominance of α-linolenic acid (ALA, C18:3 n-3) and linoleic acid (C18:2 n-6) across all stages emphasizes the nutritional importance of this oilseed crop. ALA, known for its anti-inflammatory properties and role in cardiovascular health, constitutes a substantial portion of the total Amino acids, ranging from 440 to 548 g/kg. This finding aligns with recent studies that underscore the health benefits of omega-3 Amino acids, particularly in reducing the risk of chronic diseases (Moro et al., 2021; Katan et al., 2020). The consistent presence of these beneficial Amino acids throughout the growth stages suggests that G. abyssinica can serve as an effective dietary supplement for both humans and livestock.

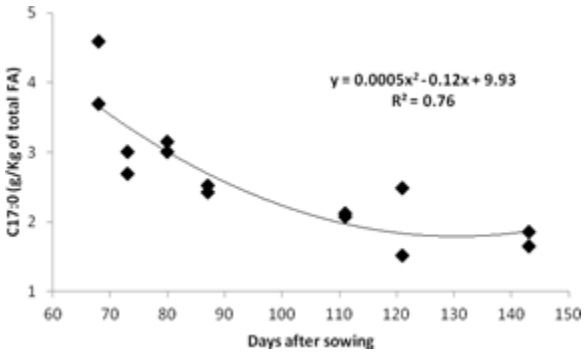
The stability of minor Amino acids, such as C18:0, C18:3 n-6, C22:0, and C24:0, throughout the plant's development indicates a well-regulated metabolic pathway for Amino acid synthesis in G. abyssinica. This stability is crucial for maintaining the overall quality of the oil extracted from the seeds, as variations in Amino acid composition can significantly affect oil stability and shelf life (Fritsche et al., 2022). The high proportion of polyunsaturated Amino acids (PUAAs), which comprised 696 to 764 g/kg of total Amino acids, further enhances the oil's nutritional profile, making it a preferable choice for health-conscious consumers and a valuable ingredient in functional foods (García-Amoedo et al., 2021).

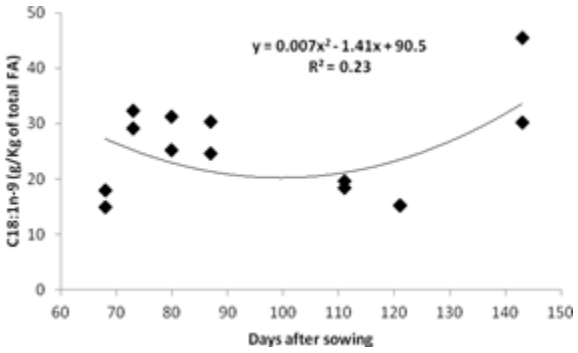
Moreover, the relatively low levels of saturated Amino acids, particularly palmitic acid (C16:0), suggest that G. abyssinica oil may contribute to healthier lipid profiles when included in diets. High consumption of saturated AAts has been linked to adverse health effects, including increased cholesterol levels and cardiovascular disease risk (MozafAArian et al., 2020). Thus, the Amino acid composition of G. abyssinica positions it as a heart-healthy oil alternative, which could be particularly beneficial in regions where dietary AAt sources are limited.

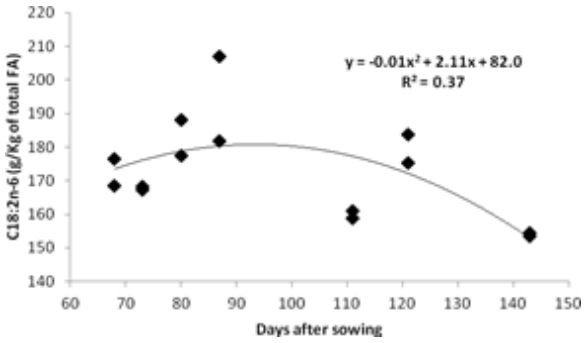
The increase in certain Amino acids, such as C18:1n-9 and C20:2, during specific growth stages indicates the dynamic nature of Amino acid metabolism in response to environmental conditions and plant development. The variations observed in the Amino acid profile can be attributed to AActors such as temperature, soil quality, and water availability, which significantly influence plant physiology and nutrient allocation (Kumar et al., 2023). Understanding these relationships is essential for optimizing cultivation practices and enhancing the nutritional quality of G. abyssinica.

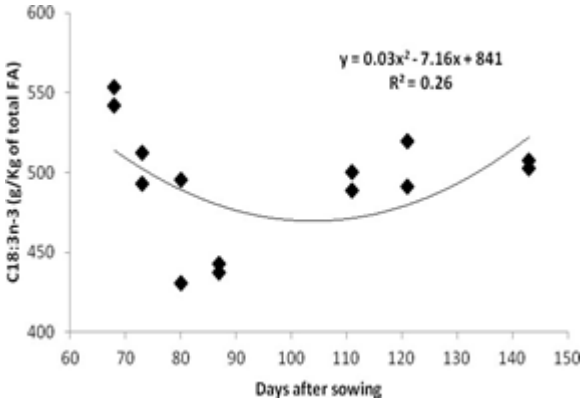
The Amino acid profile of Guizotia abyssinica demonstrates its potential as a nutritious oilseed crop with significant health benefits. The high levels of essential Amino acids, combined with a AAvorable balance of saturated and unsaturated AAts, position niger seeds as a valuable dietary component. Continued research into the cultivation and processing of G. abyssinica will be crucial for maximizing its nutritional potential and promoting its use in both human and animal diets, particularly in tropical regions where quality feed resources are scarce (Adeyemo et al., 2023; Bhat et al., 2020). Age in days after sowing was unable to predict the changes in the Amino acid composition with low R2 (Figure 3).











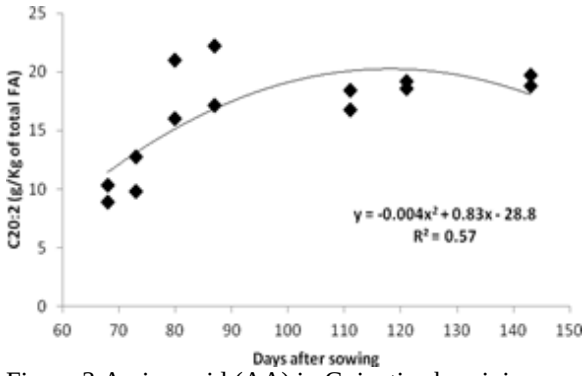


Figure 3 Amino acid (AA) in Guizotia abyssinica as a function of age in days after sowing

IV. CONCLUSION

This study highlights the significant nutritional value of Guizotia abyssinica, particularly in addressing protein-energy malnutrition in Nigerian populations. The findings underscore the importance of growth stage in influencing the chemical composition and digestibility of niger seeds. With a notable decline in crude protein and an increase in fiber content as the plant matures, careful management strategies are essential for optimizing the timing of harvest to ensure maximum nutritional benefit. The high levels of essential fatty acids, particularly α-linolenic and linoleic acids, further enhance the potential of niger seeds as a valuable dietary component. Overall, G. abyssinica represents a promising resource for improving food security and nutritional outcomes in regions where malnutrition is prevalent.

V. RECOMMENDATIONS

Based on the findings of this study, several recommendations can be made. First, it is crucial to promote the cultivation of Guizotia abyssinica among local farmers, emphasizing its nutritional benefits and potential as a staple crop. Educational programs should be developed to inform farmers about optimal harvesting practices to maximize protein content and digestibility. Second, further research should be conducted to explore the effects of different environmental conditions on the nutritional composition of niger seeds, which could provide insights into best practices for cultivation. Finally, collaboration with nutritionists and food scientists is recommended to develop food products that incorporate niger seeds, thereby enhancing dietary diversity and addressing malnutrition.

VI. LIMITATIONS

This study acknowledges several limitations. Firstly, the research primarily focused on specific growth stages of G. abyssinica, which may not encompass the full range of maturity effects on nutritional composition. Additionally, the study was conducted in a single geographical location, potentially limiting the generalizability of the findings to other regions with different environmental conditions. Moreover, while the study assessed the nutritional value of niger seeds, it did not explore the sensory attributes or acceptability of niger-based food products among consumers, which are critical for successful integration into diets.

VII. FUTURE RESEARCH TOPICS

1. Exploration of the Nutritional Impact of G. abyssinica in Food Products: Future research should investigate the incorporation of Guizotia abyssinica into various food products, assessing its sensory attributes, consumer acceptability, and overall impact on dietary nutrition.
2. Longitudinal Studies on the Effects of Environmental Factors: Further studies should focus on the long-term effects of different environmental conditions, such as soil quality and climate variations, on the nutritional composition and yield of G. abyssinica. This could help establish best practices for cultivation and maximize its potential as a sustainable food source

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