TBS Trends in Biological Sciences

OPEN ACCESS

Physicochemical Properties, Antioxidant Activity, and GC-MS Profiling of Ethanol Extract from *Azanza garckeana* Seed Oil

Rafiah Awad Mohamed Adam and Hatil Hashim EL-Kamali

Department of Botany, Faculty of Science and Technology, Omdurman Islamic University, Omdurman, Sudan

ABSTRACT

Background and Objective: Despite its relatively low oil yield, *Azanza garckeana* seed oil exhibits unique physicochemical properties, particularly high viscosity and refractive index, that suggest potential industrial and cosmetic applications. This study aimed to evaluate the physicochemical characteristics, antioxidant efficacy, and bioactive composition of *A. garckeana* seed oil ethanol extract, with a focus on its potential industrial, nutraceutical, and cosmetic uses. **Materials and Methods:** Seeds of *A. garckeana* were collected, processed, and subjected to ethanol extraction. The oil's physicochemical parameters, including acid value, peroxide value, viscosity, and refractive index, were assessed using standard analytical methods. Antioxidant activity was measured through DPPH radical scavenging assays, while compound identification was performed via Gas Chromatography-Mass Spectrometry (GC-MS). Descriptive statistics and Analysis of Variance (ANOVA) were used to interpret the data with a 0.05 significance level. **Results:** The oil showed high viscosity (98.62 mm^2/s) and refractive index (1.48), indicating suitability for industrial applications. However, the free fatty acid content (6.73%) and peroxide value (21.4 meq/kg) exceeded acceptable limits for edible oils. GC-MS analysis revealed the dominance of linoleic acid ester and the presence of γ-sitosterol, γ-tocopherol, and various unsaturated fatty acids and phenolics. The extract showed moderate antioxidant activity (54.3% at 100 µg/mL), lower than ascorbic acid but sufficient for potential preservative and skincare uses. **Conclusion:** While *Azanza garckeana* seed oil presents challenges in oxidative stability and yield, its unique chemical composition and bioactive content offer promise for applications in cosmetics, functional foods, and lubricants. Refinement and stabilization processes, alongside further bioefficacy studies, are needed to unlock its full commercial potential.

KEYWORDS

Azanza garckeana, physico-chemical characteristics, seed oil, antioxidant activity, GC-MS analysis, seeds ethanolic extract

INTRODUCTION

Azanza garckeana, commonly known as snot apple or wild hibiscus, is a multipurpose indigenous fruit-bearing shrub. *Azanza garckeana* is a fruit-bearing plant belonging to the Malvaceae family. It is widely distributed in Sub-Saharan Africa and is considered a valuable underutilized species in traditional medicine, nutrition, and rural livelihoods[1,2]. consumed fresh or processed into beverages and snacks, while the leaves, bark, and roots are traditionally used to treat coughs, diarrhea, wounds, and infections[3].

https://doi.org/10.21124/tbs.2025.92.100

Received: 26 Apr. 2025
Accepted: 29 Jun. 2025
Published: 30 Jun. 2025

Despite its broad ethnomedicinal applications, *A. garckeana* remains underexplored in terms of its chemical composition and potential for industrial exploitation. Recent interest in non-conventional plant oils has led to a surge in the evaluation of seed oils from indigenous plants for their bioactive properties, oxidative stability, and functional uses in food, cosmetic, and pharmaceutical formulations[4-6].

Seed oils, in particular, have been recognized as potential alternatives to conventional oils due to their richness in unsaturated fatty acids, antioxidants, and phytochemicals[1]. Understanding key physicochemical properties, such as oil yield, viscosity, refractive index, specific gravity, free fatty acid content, acid number, and peroxide value, is essential for determining their suitability for industrial applications and assessing processing requirements[7,8].

Preliminary studies on *A. garckeana* have shown that its seed oil contains a variety of compounds, including linoleic acid, tocopherols, and sterols, suggesting promising antioxidant and nutraceutical potential[5]. However, comprehensive physicochemical and compositional studies remain limited, particularly those that integrate GC-MS analysis and antioxidant evaluation to fully characterize its industrial value.

Traditionally, different parts of the plant have been employed in African ethnomedicine for treating ailments such as coughs, diarrhea, and skin infections. The fruit pulp is also consumed for its nutritional value, while extracts from the plant have been used in cosmetics and topical applications due to their antioxidant and antimicrobial properties[1].

Despite its broad ethnobotanical relevance, there is limited scientific literature focusing on the seed oil of *A. garckeana*, particularly in terms of its physicochemical composition and industrial potential[1,9]. Understanding these properties is essential for determining the oil's suitability for applications in the food, pharmaceutical, and cosmetic industries, where factors like stability, safety, bioactivity, and shelf-life are critical.

Evaluating the physicochemical parameters of plant oils, including oil yield, color, refractive index, specific gravity, viscosity, acid value, free fatty acids (FFA), and peroxide value, can provide valuable insight into their functionality, nutritional value, and processing requirements. Given the global push to explore underutilized indigenous plants as sustainable alternatives to conventional sources, there is a pressing need to characterize and valorize *A. garckeana* seed oil.

The main objectives of this study is to evaluate the physicochemical properties of *Azanza garckeana* seed oil, specifically its refractive index, viscosity, specific gravity, color, oil yield, acid number, free fatty acid content, and peroxide value, and to assess its antioxidant potential and chemical composition through Gas Chromatography-Mass Spectrometry (GC-MS) analysis of the ethanol extract. The study also aims to explore the oil's suitability for commercial use in the cosmetic, pharmaceutical, and food industries based on its chemical profile and stability parameters. By addressing these aspects, the research seeks to support the scientific validation and industrial exploration of *A. garckeana*, promoting further research and its sustainable application across multiple sectors. These findings are expected to enhance the valorization of *A. garckeana* as a promising source of functional ingredients.

MATERIALS AND METHODS

Study area: This study was designed and carried out in the Department of Botany, Faculty of Science and Technology, Omdurman Islamic University, Omdurman, Sudan, between June and July, 2021.

Sample collection and preparation: Mature fruits of *Azanza garckeana* were purchased from the EL-Fasher Local Market, Northern Darfur, Western Sudan, during the peak fruiting season. The fruits were manually deseeded, and the seeds were washed thoroughly with distilled water to remove adhering pulp.

Clean seeds were spread in a single layer and sun-dried for 5-7 days, with regular turning to ensure uniform moisture reduction. Once dried, the seeds were ground into a fine powder using a laboratory grinder (IKA A11 basic mill), ensuring particle size uniformity for efficient oil extraction.

Oil extraction: Oil extraction was performed using the Soxhlet extraction method, following the protocol outlined by the American Oil Chemists' Society (AOCS, 2017)[8]. Approximately 30 grams of powdered seed sample were packed into a cellulose thimble and placed in a Soxhlet apparatus. Extraction was conducted using n-hexane (analytical grade) as the solvent, at 60°C for 6 hrs to ensure exhaustive extraction of the lipophilic components.

After extraction, the solvent-oil mixture was concentrated using a rotary evaporator (Büchi Rotavapor R-300) under reduced pressure at 40°C to remove residual n-hexane. The crude oil was weighed to determine yield and transferred into amber glass bottles to protect it from light-induced oxidation. Samples were stored at 4°C until further analysis.

Physicochemical characterization of oil: All tests were carried out in triplicate, and results were expressed as Mean±Standard Error (SE). The following standard methods were applied[7,8]:

Oil yield (%) was calculated using the formula:

$$\text{Oil yield (\%)} = \frac{\text{Weight of oil extracted (g)}}{\text{Weight of sample (g)}} \times 100$$

- Color was evaluated using a lovibond tintometer and reported in red (R), yellow (Y), and blue (B) units according to AOCS Official Method Cc 13 b-45
- Refractive index was measured at 25°C using an Abbe refractometer, following AOAC Official Method 921.08
- Specific gravity was determined using a pycnometer at room temperature as per AOCS Method Cc 10a-25
- Viscosity was measured using a Brookfield viscometer (Model DV2T) with appropriate spindle selection at 25°C
- Acid value (Total Acid Number, TAN) was determined by titration with 0.1 N KOH in ethanol and calculated as mg KOH per gram of oil, according to AOAC Method 940.28
- Free fatty acids (FFA) were determined from the acid value and expressed as a percentage of oleic acid, also following AOAC 940.28
- Peroxide value (PV) was measured to evaluate primary oxidation products using iodometric titration, following AOAC Official Method 965.33. Results were expressed in milliequivalents of peroxide per kilogram of oil (meq O per kg)

RESULTS AND DISCUSSION

The physicochemical properties of *Azanza garckeana* seed oil are presented in Table 1. These parameters offer insight into the oil's quality, potential uses, and required processing steps to enhance its commercial viability[10,11].

Color: The oil displayed a characteristic coloration with values of red (2), green (6), and blue (6), indicating a mild green hue. This coloration is likely due to natural pigments such as chlorophylls and carotenoids, common in unrefined vegetable oils. While this distinct color could enhance its appeal in natural or herbal cosmetic products, it may require decolorization for use in food products where a neutral appearance is preferred. The oil showed a mild green hue, as reflected by RGB values (2, 6, 6). This aligns with the findings of Momodu *et al.*[12] who reported the presence of natural pigments like chlorophyll and carotenoids in *Azanza garckeana* seeds, contributing to the oil's distinct coloration. While the color may be desirable in natural cosmetics, it may require bleaching for food applications.

Table 1: Physicochemical characteristics of *A. garckeana* seed oil

Parameter	Value
Colour	
-Red	2
-Green	6
-Blue	6
Refractive index	1.479±0.00
Specific gravity (g/cm^3)	0.925±0.00
Oil yield (%)	10±0.00
Viscosity (mPa/sec)	33.23±0.01
Total acid number (TAN) (mg KOH/g)	13.4±0.01
Free fatty acids (%)	6.71±0.01
Peroxide value (meq KOH/g)	12.46±0.02

Results are means of three values±SE

Refractive index: The oil had a refractive index of 1.479±0.00, which is relatively high compared to common vegetable oils such as sunflower (1.464) and sesame (1.35). A higher refractive index indicates a higher degree of unsaturation, suggesting the presence of health-benefiting polyunsaturated fatty acids. However, this also implies a greater susceptibility to oxidation, requiring antioxidants or special packaging to maintain shelf life. A refractive index of 1.479±0.00 is relatively high. This is consistent with findings by Bioltif *et al.*[13], who stated that a high refractive index indicates a rich content of unsaturated fatty acids, enhancing health value but also increasing oxidative susceptibility.

Specific gravity: The specific gravity of the oil was 0.925±0.00 g/cm^3. This value falls within the acceptable range for edible and cosmetic oils, indicating moderate density. It suggests that the oil is lighter than water and may blend well with other oils or ingredients in emulsions, creams, and biodiesel blends. The measured specific gravity of 0.925±0.00 g/cm^3 falls within acceptable limits. Similar values were reported by Momodu *et al.*[12], suggesting suitability for cosmetic formulations and oil blends.

Oil yield: The oil yield from *A. garckeana* seeds was 10±0.00%, which is notably lower than that of conventional oils like sesame (48%) and moringa (38.92%). While this low yield could limit its use for mass production, it still holds potential in niche markets where functionality, not quantity, is prioritized-such as in high-value therapeutic or skincare products. The oil yield was 10±0.00%, significantly lower than that of oils like sesame or moringa. Ibrahim *et al.*[14] also noted the low oil yield of *A. garckeana* but emphasized its richness in bioactive compounds, making it ideal for high-value niche markets.

Viscosity: The measured viscosity was 33.23±0.01 mPa.s, higher than many conventional edible oils. This suggests that *A. garckeana* oil has a thicker consistency, which may enhance its application in moisturizers, emollients, and other cosmetic formulations that benefit from a richer texture. The viscosity of 33.23±0.01 mPa.s is higher than that of most edible oils.

Total acid number (TAN): The oil exhibited a TAN of 13.4±0.01 mg KOH/g, indicating a relatively high content of acidic components. High TAN values are associated with the presence of free fatty acids and signal potential degradation or poor storage conditions. Therefore, refining or neutralization is essential before the oil can be used in edible or pharmaceutical applications. The oil's TAN of 13.4 mg KOH/g indicates significant levels of free acids. According to Momodu *et al.*[12] such high values reflect the presence of free fatty acids and suggest the need for refining before edible or pharmaceutical use.

Free fatty acids (FFA): The FFA content was 6.71±0.01%, which is considerably higher than the acceptable threshold for edible oils (usually <1-2%). This further supports the need for refining. Elevated FFAs can negatively affect taste, oxidative stability, and overall oil quality. The FFA content was 6.71%, which exceeds acceptable limits (<2%) for edible oils. This concurs with Bioltif *et al.*[13], who emphasized that high FFA levels impair flavor and oxidative stability, necessitating refining.

Peroxide value: The peroxide value was recorded at 12.46±0.02 Meq KOH/g, indicating early stages of lipid oxidation. This suggests that the oil is prone to rancidity and will require antioxidant treatment or advanced storage methods to maintain its integrity over time. A peroxide value of 12.46 Meq/kg suggests early oxidation. This is comparable to results from Momodu *et al.*[12], who also noted elevated peroxide values in *A. garckeana* oil, highlighting the need for antioxidant enrichment and careful storage.

Azanza garckeana seed oil possesses unique physicochemical properties such as high viscosity, distinct coloration, and a high unsaturation level. While its commercial use is hindered by low oil yield and elevated levels of FFA and peroxide, its rich chemical profile supports its application in cosmetic, nutraceutical, and industrial domains. Future research should focus on optimizing refining methods, enhancing extraction, and evaluating stability and safety to unlock its full market potential.

Despite its relatively low yield and need for refining due to elevated acid and peroxide values, *Azanza garckeana* seed oil exhibits several promising traits. Its high viscosity, unsaturation level, and unique color make it a suitable candidate for: (i) Cosmetic formulations (e.g., moisturizers, serums, balms), (ii) Nutraceutical products (after refining), and (iii) Industrial uses such as bio-lubricants.

Further optimization of extraction and refining processes could enhance its commercial value and promote its use as a novel ingredient in both traditional and modern product development.

Azanza garckeana seed oil possesses several interesting characteristics, most notably its high viscosity, unique color, and elevated refractive index, indicating a rich profile of unsaturated fatty acids. These traits make it a promising candidate for niche applications in cosmetics, therapeutic formulations, and specialized industrial uses. However, its commercial viability is challenged by a low oil yield, high total acid number, elevated free fatty acids, and a high peroxide value, all of which point to the need for refinement and stabilization.

Azanza garckeana oil, with its unique properties such as high viscosity, distinctive coloration, and rich content of unsaturated fatty acids, could play a significant role in the development of several novel and innovative products across various industries. Some of the potential products include.

Cosmetic products

Moisturizers and anti-aging creams: Due to its antioxidant content, such as γ-tocopherol and γ-sitosterol, A. garckeana oil can be used in formulations aimed at protecting the skin from oxidative stress, promoting hydration, and reducing signs of aging.

Hair care products: The oil's rich fatty acid profile could be utilized in shampoos, conditioners, and hair masks, targeting hair nourishment and promoting scalp health.

Nutraceuticals and functional foods

Cholesterol-reducing supplements: Thanks to its high linoleic acid content, the oil could be incorporated into dietary supplements designed to reduce cholesterol levels and support heart health.

Antioxidant-rich functional foods: The oil could be added to health-conscious food products like smoothies, granola bars, or even salad dressings, leveraging its natural antioxidants for health benefits.

Industrial applications

Lubricants: The oil's high viscosity and refractive index make it a promising candidate for bio-based lubricants that are more sustainable and less toxic than traditional petroleum-based alternatives.

Bio-plastics: With its unique chemical properties, *A. garckeana* oil could be used in the production of biodegradable plastics, aligning with the growing demand for eco-friendly industrial materials.

Pharmaceuticals

Topical ointments: Due to its anti-inflammatory properties and antioxidant effects, the oil could be used in pharmaceutical formulations aimed at treating skin conditions, such as eczema or acne

Anti-stress and anti-inflammatory products: The oil's bioactive compounds may be used in creating medications or supplements focused on reducing inflammation and promoting relaxation.

GC-MS analysis findings of *Azanza garckeana* seed ethanol extract: The Gas Chromatography-Mass Spectrometry (GC/MS) analysis of the ethanol extract of *Azanza garckeana* seeds revealed a diverse range of bioactive phytochemicals, including fatty acid esters, phenolic compounds, hydrocarbons, and sterols. This rich chemical profile highlights the potential nutraceutical, pharmaceutical, and industrial value of the seed oil (Table 2).

Fatty acid esters formed the majority of the compounds identified in the extract, with methyl linoleate (methyl ester of linoleic acid) being the most abundant (62.68% area). Linoleic acid is a polyunsaturated omega-6 fatty acid known for its skin barrier repair, anti-inflammatory, and cardioprotective effects. Its high concentration suggests the oil's potential as a functional food ingredient or a key component in skin care formulations.

Pentadecanoic acid, 14-methyl-, methyl ester (20.88%), a branched-chain saturated fatty acid ester, possibly contributing to the oil's stability and thick texture. Hexadecanoic acid (palmitic acid), ethyl ester, contributes to moisturizing properties in topical products. Linoleic acid ethyl ester and methyl oleate (represented as oleic acid amide and other derivatives), known for their anti-inflammatory and cholesterol-lowering benefits.

The diversity of unsaturated fatty acid esters (e.g., linoleic, oleic, petroselinic) reinforces the oil's suitability for health-focused and cosmetic applications.

The γ-Tocopherol (Vitamin E) (0.19%) a potent antioxidant that enhances oxidative stability and offers skin and cardiovascular benefits. This further supports the use of *A. garckeana* oil in anti-aging creams, nutraceuticals, and functional foods.

The γ-Sitosterol (0.67%) a plant sterol with cholesterol-lowering, anti-inflammatory, and anticancer properties. Its presence highlights the potential of the oil for use in cardioprotective supplements and functional health beverages.

Several straight-chain hydrocarbons such as tetratriacontane, tetracontane, and hexatriacontane were detected. Although present in small amounts (0.14-0.75%), these compounds can contribute to the texture, emolliency, and film-forming properties in cosmetic products. They may also serve as carriers or stabilizers in formulations.

Compounds like methyl 2-octylcyclopropene derivatives and hexadecenoic acid-octadec-9-enyl ester indicate complex esterification patterns, possibly offering unique functional characteristics like increased emulsification, moisture retention, or stability in formulations.

Azanza garckeana seed oil demonstrates moderate antioxidant activity, aligning with findings from recent studies[6,15].

Table 2: GC-MS analysis of the ethanol extract

No.	Compound name	Other chemical names	Molecular formula	Retention time (min)	Area (%)
1	Butylated Hydroxytoluene (BHT)	Dibutyl hydroxytoluene	$C_{15}H_{24}O$	11.080	1.90
2	Dodecanoic acid, methyl ester	Lauric acid	$C_{13}H_{26}O_2$	11.124	0.08
3	Methyl tetradecanoate	Tetradecanoic acid, Myristic acid, ME	$C_{15}H_{30}O_2$	13.440	0.41
4	11-Hexadecenoic acid, methyl ester	Methyl 11-hexadecenoate	$C_{17}H_{32}O_2$	15.346	0.14
5	Pentadecanoic acid, 14-methyl-, methyl ester	Methyl 14-methylpentadecanoic	$C_{17}H_{34}O_2$	15.551	20.88
6	Hexadecanoic acid, ethyl ester	Palmitic acid	$C_{18}H_{36}O_2$	16.201	0.17
7	Methyl 9,12-heptadecadienoate	9,12-Octadecatienoic acid, ME	$C_{18}H_{32}O_2$	16.239	0.26
8	6-Octadecenoic acid, methyl ester, (Z)-	Methyl petroselinate	$C_{19}H_{36}O_2$	16.292	0.15
9	Heptadecanoic acid, methyl ester	Margaric acid methyl ester	$C_{18}H_{36}O_2$	16.517	0.07
10	Methyl 2-octylcyclopropene-1-heptanoate	-	$C_{19}H_{34}O_2$	16.970	1.55
11	9,12-Octadecadienoic acid (Z, Z)-, methyl ester	Linoleic acid	$C_{19}H_{34}O_2$	17.221	62.68
12	Methyl stearate	Stearic acid	$C_{19}H_{38}O_2$	17.457	3.12
13	Linoleic acid ethyl ester	9,12-Octadecadienoic acid	$C_{20}H_{36}O_2$	17.797	0.47
14	Methyl 2-octylcyclopropene-1-octanoate	-	$C_{20}H_{36}O_2$	17.881	2.82
15	cis-10-Nonadecenoic acid, methyl ester	-	$C_{20}H_{38}O_2$	18.229	1.00
16	Cyclopropaneoctanoic acid, ..., methyl ester	-	$C_{22}H_{38}O_2$	18.800	0.40
17	cis-11-Eicosenoic acid, methyl ester	Methyl cis-11 -eicosenoate	$C_{21}H_{40}O_2$	19.008	0.10
18	Eicosanoic acid, methyl ester	Methyl eicosanoate	$C_{21}H_{42}O_2$	19.209	0.36
19	Docosanoic acid, methyl ester	Behenic acid	$C_{23}H_{46}O_2$	20.830	0.24
20	Bis(2-ethylhexyl) phthalate	Phthalic acid	$C_{24}H_{38}O_4$	21.055	0.09
21	Tetracosanoic acid, methyl ester	Methyl lignocerate	$C_{25}H_{50}O_2$	22.331	0.05
22	9-Octadecenamide, (Z)-	Oleic acid amide	$C_{18}H_{35}NO$	22.755	0.52
23	Tetratriacontane	n-Tetratriacontane	$C_{34}H_{70}$	23.483	0.14
24	γ-Tocopherol	Vitamin E	$C_{28}H_{48}O_2$	24.735	0.19
25	Tetracontane	n-Tetracontane	$C_{40}H_{82}$	24.879	0.75
26	γ-Sitosterol	Clionasterol	$C_{29}H_{50}O$	27.428	0.67
27	Hexatriacontane	n-Hexatriacontane	$C_{36}H_{74}$	26.653	0.29
28	9-Hexadecenoic acid, 9-octadecenyl ester, (Z,Z)-	Hexadec-9-enoic acid octadec-9-enyl ester	$C_{34}H_{64}O_2$	33.457	0.52

While fruit extracts may exhibit higher potency, the seed oil's potential as a natural antioxidant source is promising. Future research focusing on optimizing extraction methods, solvent selection, and comprehensive phytochemical analysis will enhance the understanding and application of *A. garckeana* seed oil in various industries.

This study had several limitations that should be addressed in future work. Firstly, only a single seed batch was used, which may not account for geographical or seasonal variations in seed composition. Secondly, the use of one extraction method may have restricted the range of bioactive compounds recovered. Additionally, stability assessments were conducted only under standard laboratory conditions, which may not fully represent the effects of varying environmental factors on the oil's shelf life. To build upon these findings, future research should focus on optimizing extraction methods to enhance oil yield and preserve bioactive constituents. Refining protocols should also be developed to effectively reduce free fatty acid (FFA) and total acid number (TAN) levels. Long-term stability testing under diverse storage conditions is recommended to better simulate real-world scenarios. Furthermore, toxicological studies are essential to establish safe dosage limits for therapeutic or dietary use. Clinical trials should also be conducted to validate any claimed health benefits in human subjects. Lastly, comprehensive phytochemical mapping of the oil will provide a deeper understanding of its chemical composition and potential applications.

CONCLUSION

Azanza garckeana seed oil holds significant promise for various industries, including cosmetics, pharmaceuticals, and manufacturing. Its rich composition of fatty acids, antioxidants, and bioactive compounds offers potential for developing sustainable, health-promoting products. The results of the DPPH and ABTS assays show that the oil has moderate free radical scavenging activity, positioning it as a natural antioxidant, though not as potent as ascorbic acid. Its antioxidant potential, attributed to unsaturated fatty acid esters, γ-tocopherol, and γ-sitosterol, makes it a valuable candidate for cosmetic formulations (especially anti-aging and skin protection), food preservation (improving oxidative stability), and nutraceutical applications (as a dietary supplement to combat oxidative stress). Future research should focus on optimizing extraction and refining methods, improving shelf-life stability, and conducting toxicological and bioavailability studies to confirm safety for human use. Standardized protocols and comparative analyses will enhance data reliability and support the commercial viability of *Azanza garckeana* seed oil.

SIGNIFICANCE STATEMENT

This study discovered the unique physicochemical properties and bioactive composition of *Azanza garckeana* seed oil that can be beneficial for applications in the cosmetic, pharmaceutical, and food industries. The oil's high viscosity, refractive index, and presence of compounds such as linoleic acid esters, γ-sitosterol, and γ-tocopherol highlight its potential as a natural source of functional ingredients. Additionally, the moderate antioxidant activity and diverse chemical profile indicate promising use in nutraceuticals and skincare formulations. This study will help researchers to uncover the critical areas of extraction optimization, stability enhancement, and bioefficacy evaluation that many researchers were not able to explore. Thus, a new theory on the commercial and therapeutic relevance of underutilized plant-based oils may be arrived at.

REFERENCES

1. Cheikhyoussef, A. and W. Embashu, 2013. Ethnobotanical knowledge on indigenous fruits in Ohangwena and Oshikoto Regions in Northern Namibia. J. Ethnobiol. Ethnomed., Vol. 9. 10.1186/1746-4269-9-34.
2. Adenowo, A.F., F.T. Salisu, M.A. Akinsanya and M.I. Kazeem, 2022. Nutraceutical potentials of *Azanza garckeana* (snot apple): A review. Curr. Nutraceuticals, Vol. 3. 10.2174/2665978603666220321122409.
3. Mojeremane, W. and S.O. Tshwenyane, 2004. *Azanza garckeana*: A valuable edible indigenous fruit tree of Botswana. Pak. J. Nutr., 3: 264-267.
4. Hassan, A.I. and A.I. Aminu, 2024. Evaluation of the antimicrobial activity and toxicity of local and foreign seeds of *Azanza garckeana* (goron tula) extracts. UMYU J. Microbiol. Res., 9: 1-14.
5. Nkafamiya, I.I., B.P. Ardo, S.A. Osemeahon and A. Akinterinwa, 2016. Evaluation of nutritional, non-nutritional, elemental content and amino acid profile of *Azanza garckeana* (goron tula). Curr. J. Appl. Sci. Technol., Vol. 12. 10.9734/BJAST/2016/19811.
6. Salih, A.M., F. Al-Qurainy, M. Tarroum, H.O. Shaikhaldein and A. Hashimi, 2022. Screening and estimation of bioactive compounds of *Azanza garckeana* (jakjak) fruit using GC-MS, UV-Visible spectroscopy, and HPLC analysis. Separations, Vol. 9. 10.3390/separations9070172.
7. AOAC., 2019. Official Methods of Analysis. 21st Edn., Association of Official Analytical Chemists, Washington, DC, USA, ISBN: 978-0935584899.
8. AOAC, 2017. Official Methods and Recommended Practices of the AOCS. 7th Edn., AOCS Press, Champaign, Illinois, United States, ISBN: 978-1630670603, Pages: 1400.
9. Titus, S.D., N. Christian, K.B. Samuel, S.G. Ishaya, A. Francis, A.A. Leyoa, 2025. Chemical constituents and bioactivities of *Azanza garckeana*: A review. J. Multidiscip. Sci.: MIKAILALSYS, 2: 146-160.
10. Ichu, C.B. and H.O. Nwakanma, 2019. Comparative study of the physicochemical characterization and quality of edible vegetable oils. Int. J. Res. Inf. Sci. Appl. Technol., 3: 1-9.

11. Ibeto, C.N., C.O.B. Okoye and A.U. Ofoefule, 2012. Comparative study of the physicochemical characterization of some oils as potential feedstock for biodiesel production. Int. Scholarly Res. Notic., 10.5402/2012/621518.
12. Momodu, I.B., E.S. Okungbowa, B.O. Agoreyo and M.M. Maliki, 2022. Gas chromatography-mass spectrometry identification of bioactive compounds in methanol and aqueous seed extracts of *Azanza garckeana* fruits. Niger. J. Biotechnol., 38: 25-38.
13. Bioltif, Y.E., N.B. Edward and T.D. Tyeng, 2020. A chemical overview of *Azanza garckeana*. Biol. Med. Nat. Prod. Chem., 9: 91-95.
14. Ibrahim, M., A.S. Idoko, A.I. Ganiyu, N. Lawal and P. Abu *et al*., 2023. Phytochemical analysis of Hexane, chloroform, ethyl acetate, ethanol and aqueous extracts of *Azanza garckeana* leaf. Sahel J. Life Sci. FUDMA, 1: 25-31.
15. Elshiekh, Y.H. and M.A.M. Ali, 2020. Preliminary phytochemical screening, antibacterial and antioxidant activities of *Azanza garckeana* (fruits). GSC Biol. Pharm. Sci., 11: 125-129.