

## ORIGINAL RESEARCH ARTICLE

## Pilot Evaluation of *Dialium guineense* Fruit and Leaf Extracts in Inhibition of Glucose-Induced Protein Glycation and DPPH Radical: An In vitro Study

\*Hauwa Salisu Usman<sup>1</sup>, Shehu Muhammad Hassan<sup>1</sup>, Idris Zubairu Sadiq<sup>1</sup>, Christiana Oyetola Olawoyin<sup>1</sup>, Murja Ibrahim Danja<sup>2</sup> and Abdullahi Balarabe Sallau<sup>1</sup>

<sup>1</sup>Department of Biochemistry, Ahmadu Bello University, Zaria, Nigeria

<sup>2</sup>Federal University of Education, Zaria, Nigeria

### ABSTRACT

Advanced glycation end-products (AGEs) are the final products derived from the Maillard reaction, a non-enzymatic glycation of free amino groups by sugars and aldehydes. AGE formation begins under hyperglycemic or oxidative stress conditions. This work aimed to determine the anti-glycation and antioxidant potential of leaves and fruit pulp of *Dialium guineense* (black velvet tamarind). Plant materials were extracted with chloroform, methanol, and ethyl acetate using the maceration technique. Qualitative phytochemical screening was carried out alongside *in vitro* antioxidant assay (DPPH radical scavenging) and anti-glycation assay via the BSA-glucose model using spectrofluorescence, with aminoguanidine as the positive control. All experiments were carried out in triplicate, with data presented as mean  $\pm$  standard deviation (SD), and analyzed using one-way analysis of variance (ANOVA) in SPSS version 20. Phytochemicals identified include saponins, cardiac glycosides, steroids, triterpenes, flavonoids and tannins. Antioxidant activity showed that the DG methanol leaf extract had the highest activity (72.44% at 250  $\mu$ g/mL), which was highly significant ( $p < 0.05$ ) compared to the control (92.01%). For the fruit pulp, the chloroform fruit extract had the highest activity (67.09% at 500  $\mu$ g/mL). Anti-glycation activity of DG leaves showed that the methanol leaf extract had the highest activity (86.46% at 125 $\mu$ g/mL); for the fruit pulp, ethylacetate fruit extract had the highest activity (95.62% at 250 $\mu$ g/mL), which was highly significant ( $p < 0.05$ ) compared to the control (83.68%). Despite the remarkable outcome achieved, some limitations of this pilot study include the exclusion of quantitative phytochemical analysis and other assay variants, and the scope being confined to an *in vitro* medium. In conclusion, the dual potential of both fruits and leaves of *Dialium guineense* in anti-glycation and antioxidant studies adds to its pharmacological value as a potential functional food or medicinal plant.

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### INTRODUCTION

The rising incidence of lifestyle-related illnesses has spurred numerous studies on dietary antioxidants. Excessive production of chemicals resulting from the non-enzymatic multi-stage glycation process is a consequence of sedentary lifestyles, hypercaloric and high-fructose diets, and the increasing consumption of processed food components. Furthermore, advanced glycation end products (AGEs) have been shown to have a significant role in the pathogenesis of a number of metabolic disorders linked to chronic illnesses, including diabetes, cardiovascular disease, atherosclerosis, and its repercussions (Nowotny *et al.*, 2018; Zawada *et al.*, 2022).

The accumulation of Advanced Glycation End Products (AGEs) has been a significant focus of research on metabolic disorders. Glycation, a non-enzymatic process

in which reducing sugars react with amino groups of proteins, lipids, and nucleic acids, results in the formation of complex molecules known as AGEs. Cardiovascular disease, dementia, and renal dysfunction are among the chronic illnesses associated with their prevalence (Twarda-Clapa *et al.*, 2022). AGEs' pathophysiological effects are mediated by receptor interactions, especially with the Receptor for Advanced Glycation End Products (RAGE), which intensifies oxidative stress and triggers inflammatory responses (Chinchansure *et al.*, 2015; Sadeghi *et al.*, 2023).

Our body produces free radicals, such as reactive oxygen and nitrogen species, through a variety of endogenous systems, exposure to various physicochemical conditions, or pathological conditions. For healthy physiological

**Correspondence:** Hauwa Salisu Usman. Department of Biochemistry, Faculty of Life Science, Ahmadu Bello University, Zaria, Nigeria. ✉ [ummisa71@gmail.com](mailto:ummisa71@gmail.com).

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function, free radicals and antioxidants must be in equilibrium. Oxidative stress results when the body's capacity to control free radicals is exceeded. As a result, free radicals damage proteins, lipids, and DNA, leading to a variety of illnesses in humans. Therefore, applying antioxidants from outside sources can help manage this oxidative damage. By neutralizing these free radicals, antioxidants shield cells from oxidative damage (Lobo *et al.*, 2010). The DPPH (2,2-diphenyl-1-picrylhydrazyl) radical scavenging test is commonly recognized as a dependable and simple technique to evaluate the antioxidant potential of different compounds (Abuh *et al.*, 2022; Inuwa *et al.*, 2024; Isah *et al.*, 2025; Komolafe *et al.*, 2024; Muhammad, I. *et al.*, 2024; H. S. Muhammad *et al.*, 2024; I. Muhammad *et al.*, 2025; Muhammad I. *et al.*, 2024; I. Muhammad & Lawal, 2025; Musa & Imam, 2022; Nasir *et al.*, 2025; Ndu *et al.*, 2025). It enables a preliminary evaluation of the extracts' potential health benefits by measuring their capacity to donate hydrogen atoms to neutralize free radicals (Brand-Williams *et al.*, 1995).

Due to their ability to reduce oxidative stress and stop or limit the development of AGE accumulation, natural compounds have become more popular in the search for potent anti-glycation therapies (Elosta *et al.*, 2012). *Dialium guineense* (DG), also known as Black Velvet Tamarind, has emerged as one of the many botanical resources that merit further investigation. Native to West

Africa, this fruit-bearing tree has long been used in ethnomedicine, especially for its reported anti-inflammatory, anti-oxidative, and anti-diabetic qualities (Lokonon *et al.*, 2013; Besong *et al.*, 2016; Oluwole-Banjo, 2019).

Known as "Awin" in Yoruba, "Icheku" in Igbo, and "Tsamiyar kurmi" in Hausa, *Dialium guineense* (DG), or black velvet tamarind, is found in a number of West African nations, including Ghana, Sierra Leone, Senegal, and Nigeria (Besong *et al.*, 2016). The fruit is sold in local markets and is frequently eaten as a snack. Occasionally, it is used to make a non-alcoholic beverage. Furthermore, the gum from the seeds is used in Japanese cooking to improve food viscosity, and the blossoms and leaves are eaten as vegetables (Utubaku *et al.*, 2017). The tree's leaves alleviate fever and oedema, while its bark is used to treat conditions such as cancer, headaches, and dental hygiene (Ovuakporie-Uvo *et al.*, 2015). According to Besong *et al.* (2016), the fruits are traditionally used to cure wounds, malaria, pneumonia, diarrhoea, and cough. It has also been reported to help breastfeeding women in southeast Nigeria prevent genital infections. The plant is known for its saponin content, which may help promote dental health by reducing plaque and cavities (Alagbe *et al.*, 2020).



Plate 1: *Dialium guineense* fruit, fruit pulp, seeds and leaves.

To the best of our knowledge, this is the first research on the antiglycation activity of *Dialium guineense* fruit and leaf extracts. Despite a few existing studies on the antioxidant activity of the plant, all were based on methanol or aqueous extracts (Adopo *et al.*, 2024; Ebo *et al.*, 2025; Ogu *et al.*, 2013) or an n-hexane/ethanol extract (Dressman *et al.*, 2024), without considering various solvent systems. Moreover, the review on the medicinal importance of DG (Besong *et al.*, 2016) lacks reports on its antiglycation activity; hence, the need to bridge this research gap. This study aims to evaluate the anti-glycation and antioxidant properties of DG fruit and leaf extracts in vitro using different solvent systems, to assess the specific activity of the various solvents based on their polarity. Assessing their efficacy in inhibiting AGE formation and scavenging DPPH radicals will elucidate the therapeutic potential of this indigenous resource.

## MATERIALS AND METHODS

### Chemicals and Reagents

Methanol, Ethyl-acetate, Chloroform, 1,1-diphenyl-2-picrylhydrazyl (DPPH), Phosphate buffer, Ascorbic acid, Bovine serum albumin (BSA), Glucose, Phosphate-buffered saline (PBS), Trichloroacetic acid, Aminoguanidine, Distilled water, Test tubes, Beaker, Measuring cylinder, Pipette, Glass rod

### Sample Collection

*Dialium guineense* leaves and fruits were collected from a local market in Sabon gari, Zaria, Kaduna State. Plant samples were authenticated at the Herbarium Unit of the Department of Botany, Faculty of Life Science, Ahmadu Bello University, Zaria, Kaduna State, Nigeria, where a voucher number (ABU0243) was deposited.

### Preparation of Plant Crude Extracts

Air-dried whole plant materials were ground into a fine powder using a mortar and pestle. Powdered plant material (10 g) was extracted separately using 150ml each of methanol, ethyl-acetate, and chloroform. The supernatants were filtered using a Whatman No. 1 filter paper into pre-weighed glass vials and air-dried. The quantity of plant materials extracted was determined and stored in air-tight glass vials in the dark until usage.

### Phytochemical Evaluation of Plant Extracts

The presence/absence of phytochemicals in DG fruit and leaf extracts was determined using colour change or precipitate formation assays, including flavonoids (Shinoda Method), phenolic compounds (Ferric chloride), alkaloids (Dragendorff, Wagner, and Mayer Methods), triterpenes and steroids (Liebermann–Buchard Method). The results were expressed as the relative presence of the phytochemicals, considering the following symbols: presence [+] and absence [-] (Harborne, 1998; Evans, 2002).

### Antioxidant Activity of Plant Extracts

The antioxidant power of plant extracts was determined using the DPPH free radical scavenging assay as described by Shah *et al.* (2013). Briefly, 0.1 ml each of methanol, 1 mg/ml ascorbic acid, and 1 mg/ml plant extract was added, in triplicate, to the control, standard, and extracts (methanol, ethyl acetate, and chloroform), respectively. Thereafter, 3 mL of 0.24 mg/mL DPPH (prepared in methanol) was added to the test tubes. The mixture was then incubated for 5 min, followed by 30 min in the dark at 25 °C. Five different concentrations (62.5 µg/mL, 125 µg/mL, 250 µg/mL, 500 µg/mL, and 1000 µg/mL) of the control and plant samples were prepared in triplicate. The absorbance was read at 517 nm using an Agilent Cary 60 UV-Vis Spectrophotometer. Distilled water was used as the blank control to reset the instrument prior to each absorbance measurement. The percentage antioxidant or free radical scavenging activity of the extracts and ascorbic acid was determined by substituting absorbance values using the formula below:

$$\text{Antioxidant activity (\%)} = \frac{\text{Absorbance of control} - \text{Absorbance of test}}{\text{Absorbance of control}} \times 100$$

### Antiglycation Activity of Plant Extracts

The antiglycation activity of the extracts was estimated using the methods of Matsuura *et al.* (2002) and Kaewnarin *et al.* (2014). In brief, 20 µl each of 800 µg/ml BSA and 200 mM D-glucose were added, in triplicate, to test tubes labelled 'standard' and 'plant extracts' (methanol, ethyl acetate, and chloroform). Thereafter, 20 µl each of 50 mM phosphate buffer (pH 7.4) containing 0.2 g/l sodium azide was added to the test tubes labelled standard and the various plant extracts mentioned above. 1 mg/ml of both aminoguanidine and plant extract (prepared in phosphate buffer containing sodium azide) was added to test tubes labelled 'standard' and 'plant extracts,' respectively. Five different concentrations (62.5 µg/mL, 125 µg/mL, 250

µg/mL, 500 µg/mL, and 1000 µg/mL) of the control and plant samples were prepared in triplicate. Afterwards, the mixture was incubated at 37°C for 7 days. The fluorescence intensity was measured at an excitation wavelength of 370 nm and an emission wavelength of 440 nm using an Agilent Cary Eclipse Fluorescence Spectrometer. Distilled water was used as the blank control to reset the instrument prior to each absorbance measurement. The percentage antiglycation activity of the extracts and the control was calculated using mean absorbance values from the plant extracts and the control substituted in the formula below:

$$\text{Antiglycation activity (\%)} = \frac{\text{Fluorescence intensity of control} - \text{Fluorescence intensity of test}}{\text{Fluorescence intensity of control}} \times 100$$

### Data Analysis

All experiments were carried out in triplicate, with data presented as mean ± standard deviation (SD), and analyzed using one-way analysis of variance (ANOVA) in Statistical Package for the Social Sciences (SPSS) version 20 for Windows. A Duncan post hoc test was conducted to detect differences in the means of the various test solutions. P value less than 0.05 ( $p < 0.05$ ) was considered statistically significant.

## RESULT

Phytochemicals identified in ethyl acetate, chloroform, and methanol extracts of DG leaves and fruits included saponins, triterpenes, tannins, and flavonoids. Moreover, steroids and triterpenes were present in all the plant extracts evaluated. However, anthraquinones and alkaloids were not detected in all the plant extracts (Table 1).

The DPPH scavenging activity of DG fruit extract is depicted in Figure 1. The chloroform extract had the highest activity (67.09% at 500 µg/mL), which was significantly lower ( $p < 0.05$ ) than that of ascorbic acid (control). Comparatively, leaf methanol extract displayed a higher antioxidant activity (72.44% at 250µg/mL) compared to ethylacetate (57.89%) and chloroform extract (50.85%) (Figure 2). However, DPPH radical scavenging capacity between the methanol leaf extract and ascorbic acid was significantly low ( $p < 0.05$ ). All data were presented as mean ± SD of triplicate values. a-c values with different alphabets over the bars are significantly ( $p < 0.05$ ) different from each other.

Results from the antiglycation activity of *Dialium guineense* fruits is depicted in Figure 3. DG ethyl acetate fruit extract had the highest antiglycation activity (95.20% at 250 µg/mL) compared to chloroform (91.78%) and methanol (55.19%); however, this was significantly higher ( $p < 0.05$ ) than the control (aminoguanidine). Methanol leaf extract had the most antiglycation activity (86.48% at 125µg/mL) as shown in (Figure 4); however, this was significantly ( $p$

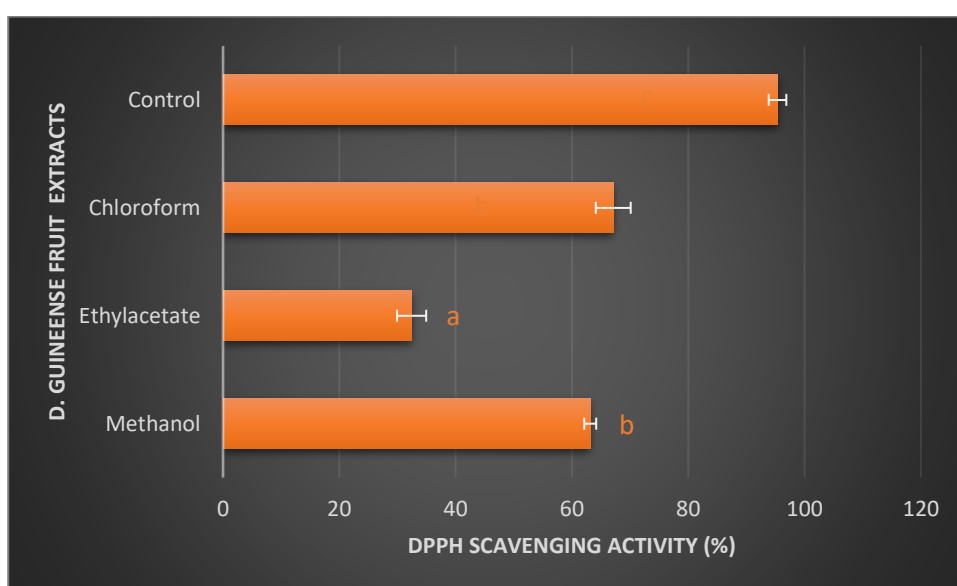
< 0.05) high compared to the control (aminoguanidine). All data were presented as mean ± SD of triplicate values.

a-d values with different alphabets over the bars are significantly ( $p < 0.05$ ) different from each other.

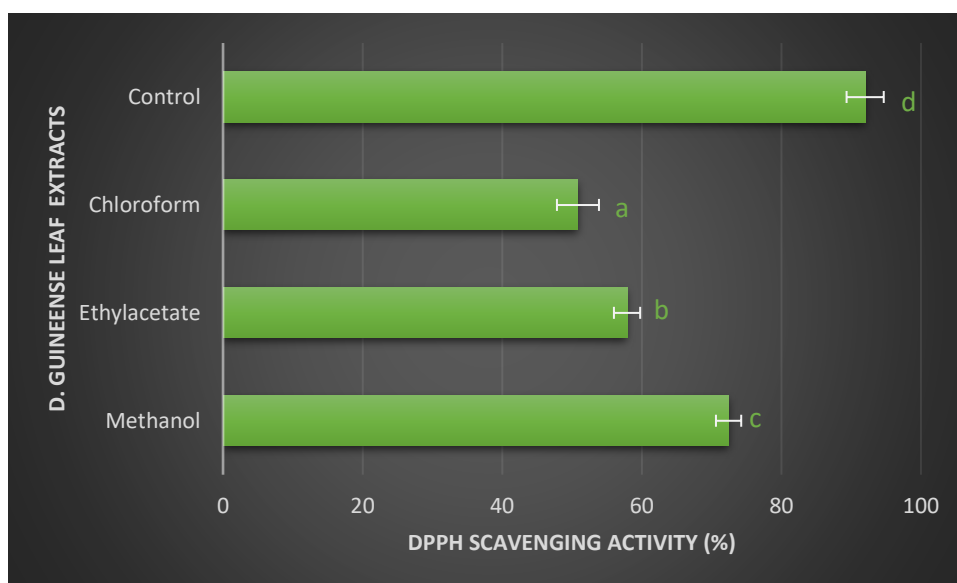
**Table 1: Phytochemical constituents of *Dialium guineense* leaves and fruits.**

Phytochemicals	DGMLE	DGELE	DGCLE	DGMFE	DGEFE	DGCFE
Saponins	+	+	-	+	-	-
Cardiac glycosides	+	+	-	+	+	-
Steroids and triterpenes	+	+	+	+	+	+
Flavonoids	-	-	+	+	-	-
Tannins	+	-	+	-	-	+
Anthraquinones	-	-	-	-	-	-
Alkaloids	-	-	-	-	-	-

**KEY:** DGMLE : *Dialium guineense* methanol leaf extract DGELE : *Dialium guineense* ethylacetate leaf extract DGCLE : *Dialium guineense* chloroform leaf extract DGMFE : *Dialium guineense* methanol fruit extract DGEFE : *Dialium guineense* ethylacetate fruit extract DGCFE : *Dialium guineense* chloroform fruit extract - : showing the absence of a phytochemical + : showing the presence of a phytochemical



**Figure 1: *In vitro* DPPH Radical Scavenging Activity of *Dialium guineense* Fruit Extracts:** data are shown as percentage DPPH scavenging activity. Data are presented as mean ± SD of triplicate values. a-c values with different alphabets over the bars are significantly ( $p < 0.05$ ) different from each other.



**Figure 2: *In vitro* DPPH Radical Scavenging Activity of *Dialium guineense* Leaf Extracts:** data are shown as percentage DPPH scavenging activity. Data are presented as mean ± SD of triplicate values. a-d values with different alphabets over the bars are significantly ( $p < 0.05$ ) different from each other.

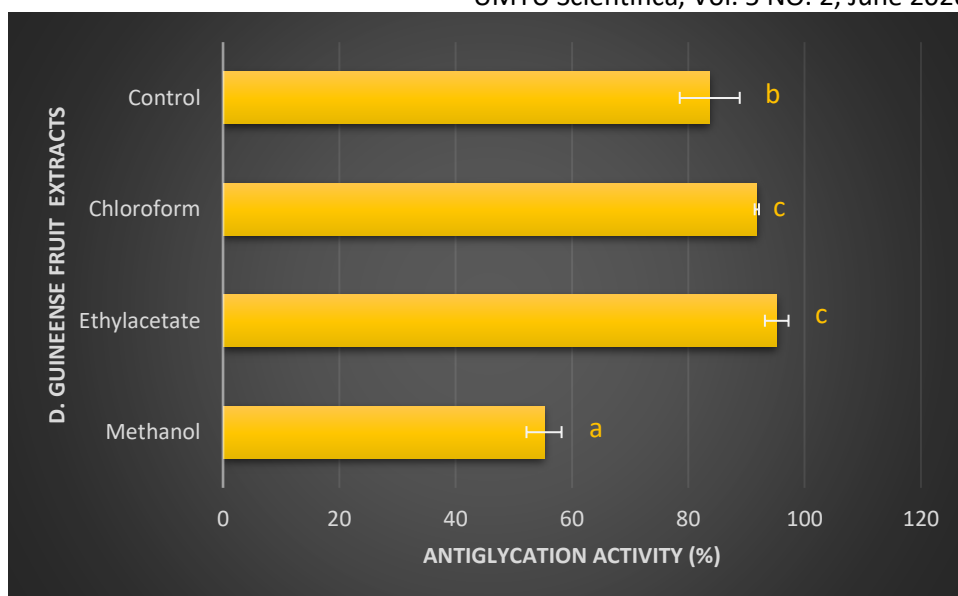


Figure 3: *In vitro* Antiglycation Activity of *Dialium guineense* Fruit Extracts: data are shown as percentage antiglycation activity. Data are presented as mean  $\pm$  SD of triplicate values. a-c values with different alphabets over the bars are significantly ( $p < 0.05$ ) different from each other.

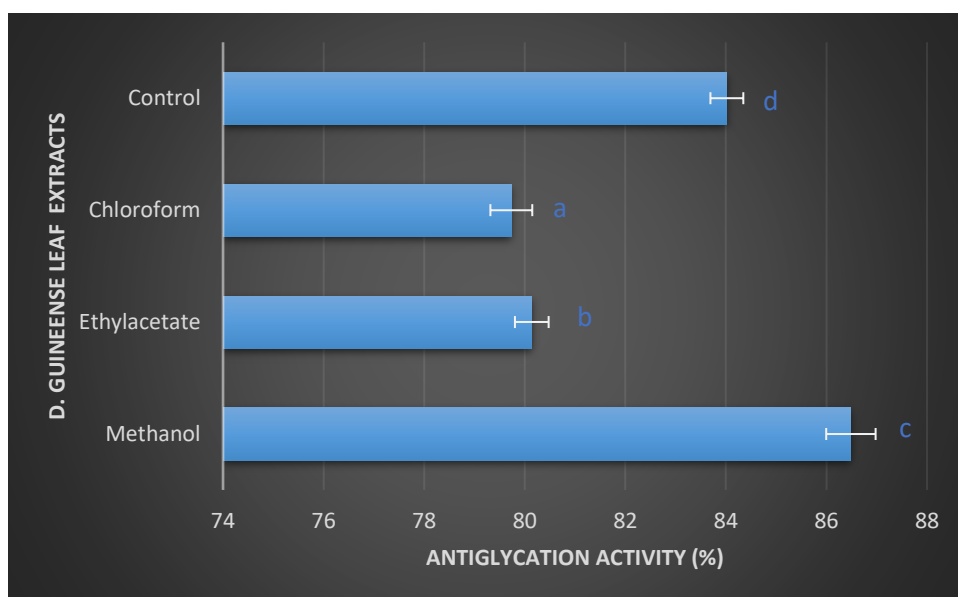


Figure 4: *In vitro* Antiglycation Activity of *Dialium guineense* Leaf Extracts: data are shown as percentage antiglycation activity. Data are presented as mean  $\pm$  SD of triplicate values. a-d values with different alphabets over the bars are significantly ( $p < 0.05$ ) different from each other.

## DISCUSSION

The present study evaluated the potential of *Dialium guineense* (DG) fruit and leaf extracts to inhibit advanced glycation end products (AGEs) and to scavenge DPPH radicals *in vitro*. The results suggest that both fruit and leaf extracts possess notable anti-glycation and antioxidant properties, which may offer therapeutic value in the management of conditions associated with oxidative stress, such as diabetes and ageing.

To the best of our knowledge, there is no existing literature on the antiglycation activity of DG fruits and leaves; hence, the need for this pilot study. In our findings, both the fruit and leaf extracts demonstrated remarkable antiglycation activity, consistent with previous studies on other plant-based extracts (Bi *et al.*, 2011; Silva *et al.*, 2022; Usman *et al.*, 2023b, 2025a). However, the fruit

extract showed higher efficacy (95.20% at 250  $\mu$ g/mL) than the control; this may be attributed to the different solvent system used. Chloroform and ethyl acetate fruit extracts had very high activity values (95% and 91%, respectively), suggesting that the bioactive principles present in these extracts are non-polar/moderately polar in nature. The leaf extract also exhibited remarkable antiglycation activity (86%). Similarly, extracts from numerous plant species, such as *Ficus racemosa*, *Ficus botryocarpa* and *Solanum macrocarpon* have shown promising anti-glycation effects (Cushnie *et al.*, 2024; Usman *et al.*, 2025b). The potential of DG extracts in this regard could offer an alternative or adjunctive approach to managing AGE-related complications, since AGEs are implicated in the pathogenesis of several chronic diseases, including diabetes, cardiovascular disease, and Alzheimer's disease (Khalid *et al.*, 2022).

The DPPH free radical scavenging activity is a widely used model for evaluating the free radical scavenging ability of various compounds. Absorbance decreased at 517 nm, resulting in a colour change from purple to yellow, as radicals were scavenged by antioxidants through the donation of hydrogen to form the stable DPPH molecule (Nandhakumar and Indumathi, 2013). In our study, the leaf methanol extract of *DG* exhibited superior scavenging activity on DPPH radical when compared to the fruit extract. This can be attributed to the presence of phytochemicals, such as saponins, cardiac glycosides, tannins, steroids, and triterpenes, in the leaves. Saponins, in particular, are known for their electron-donating properties, which enable them to neutralize free radicals efficiently. Saponins, from a variety of sources, have also been shown to have hypocholesterolemic, anticoagulant, anticarcinogenic, hepatoprotective, hypoglycemic, immunomodulatory, neuroprotective, anti-inflammatory, and antioxidant activities (Rao and Gurfinkel, 2000). Our findings align with those reported by other researchers, who have observed significant DPPH scavenging activity in various plant extracts, including those from *Moringa peregrina*, *Crataegus meyeri*, *Vernonia amygdalina*, *Carissa edulis*, *Diospyros mespiliformis*, and *Centella asiatica* (Dehshahri et al., 2012; Ekin et al., 2017; Hussien & Endalew, 2023; Usman et al., 2023a; Kalemba et al., 2024). Interestingly, the DPPH scavenging activity of the fruit extract, although slightly lower than that of the leaf extract, still demonstrated promising results. This suggests that *DG* leaves could be an alternative source of antioxidants, particularly in regions where fruit availability may be limited.

However, some key constraints of our *in vitro*-based studies include a lack of systemic interactions, poor metabolic simulation, inability to model chronic/long-term effects, and high variability between laboratories (Ghallab, 2013; Tice et al., 2013).

While this pilot study provides valuable insights into the bioactivity of *DG* fruit and leaf extracts, further research is necessary to explore the molecular mechanisms underlying their anti-glycation and antioxidant activities. It would be beneficial to identify and isolate the specific bioactive compounds responsible for these effects. Additionally, *in vivo* studies are needed to confirm *DG*'s therapeutic potential in animal models, followed by clinical trials to assess its efficacy and safety in humans. Furthermore, future studies should examine compound isolation and identification through LC-MS and orthogonal AGE assays. The emerging field of polyherbal medicine could offer enhanced therapeutic strategies by leveraging the complementary bioactive profiles of different plants.

## CONCLUSION

Our preliminary findings indicate dual potential for both the fruit and leaf extracts for anti-glycation and antioxidant activities. These findings add to the pharmacological value of *DG* as a functional food or medicinal plant, offering a potential protective effect against oxidative stress-related diseases, including cancer,

cardiovascular diseases, and neurodegeneration. By establishing a scientific basis for *DG*'s traditional medicinal uses, this study emphasizes the need for further research into the implications of *Dialium guineense* in preventing oxidative stress-related complications.

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## CONFLICT OF INTEREST

The authors declare no conflict of interest.

## AUTHORS' CONTRIBUTIONS

Conceptualisation: HSU, ABS; Laboratory experiments: COO, HSU; Data Analysis: COO, HSU, SMH, ISZ; Writing- original draft preparation: HSU, COO; Writing-review and editing: HSU, ISZ, SMH, MID, ABS; Resources: HSU, COO, SMH, MID, ABS; Supervision: HSU, ABS. All authors approved the final version of the manuscript.

## REFERENCES

- Abuh, O. L., Isah, A. A., Azeez, A. A., & Kwasi, N. B. (2022). Phytochemical screening and antioxidant activities of the bark of *Lawsonia inermis* (Henna) grown in Dekina, Kogi, Nigeria. *UMYU Scientifica*, 1(1), 274–279. [Crossref]
- Adopo, S. S. F., Kabran, G. R. M., Bagueia-Broune, F. D., Konan, K. A. P., Mamyrbekova-Bekro, J. A., & Békro, Y. A. (2024). Chemical Composition and Antioxidant Activity of *Dialium guineense* Fruit (Fabaceae), Côte d'Ivoire. *International Journal of Biochemistry Research & Review*, 33(6), 604–615. [Crossref]
- Alagbe, J., Shittu, M.D., Gbamigboye, S.O. and Oluwtobi, A.O. (2020) Proximate and Mineral Composition of Pentadiplandra Brazzeana Stem Bark. *International Journal on Intergrated Education.*; 3(11): 114-118. [Crossref]
- Besong, E.E., Balogun, M.E., Djobbissie, S.F.A., Obu, D.C. and Obimma, J.N. (2016) Medicinal and Economic Value of *Dialium guineense*. *African Journal of Biomedical Research*, 3(19):163-170. [Crossref]
- Bi, L., Tian, X., Dou, F., Hong, L., Tang, H., & Wang, S. (2012). New antioxidant and antiglycation active triterpenoid saponins from the root bark of *Aralia taibaiensis*. *Fitoterapia*, 83(1), 234–240. [Crossref]
- Brand-Williams, W., Cuvelier, M. E., & Berset, C. L. W. T. (1995). Use of a free radical method to evaluate
- Usman et al., /USci, 5(2): 091 – 099, June 2026

- antioxidant activity. *LWT-Food science and Technology*, 28(1), 25-30. [\[Crossref\]](#)
- Chinchansure, A. A., Korwar, A. M., Kulkarni, M. J., & Joshi, S. P. (2015). Recent development of plant products with anti-glycation activity: a review. *RSC Advances*, 5(39), 31113-31138. [\[Crossref\]](#)
- Cushnie, B., Jaruchotikamol, A., Laihakhot, J., & Chotson, A. (2024). *In vitro* antiglycation and antioxidant properties of ethanolic extracts of *Ficus botryocarpa* and *Ficus racemosa* fruits. *Journal of Herbed Pharmacology*, 13(3), 472-481. [\[Crossref\]](#)
- Dehshahri, S. H., Wink, M., Afsharypuor, S., Asghari, G., & Mohagheghzadeh, A. (2012). Antioxidant activity of methanolic leaf extract of *Moringa perygrina* (Forssk.) Fiori. *Research in Pharmaceutical Sciences*, 7(2), 111. [\[Link\]](#)
- Dressman, O. H., Akpan, I. O., Achugasim, O., Abayeh, O. J., & Ogalí, R. E. (2024). Physicochemical analysis and antimicrobial activity of modified and unmodified forms of extracts of *Dialium guineense* (Velvet tamarind) seed. *J. Mater. Environ. Sci.*, 15 (6), 839, 849. [\[Link\]](#)
- Ebo, P. U., Dimejesi, S. A., Umeoduagu, N. D., Ofunwa, J. O., Awari, V. G., Ekwenze, T. N., & Chinweude, C. V. (2025). Antibacterial Activity and Phytochemical Profile of *Dialium guineense* (Velvet Tamarind). *World Journal of Applied Medical Sciences*, 2(5), 15-19. [\[Link\]](#)
- Ekin, S., Bayramoglu, M., Goktasoglu, A., Ozgokce, F., & Kiziltas, H. (2017). Antioxidant activity of aqueous and ethanol extracts of *Crataegus meyeri* Pojark leaves and contents of vitamin, trace element. *Journal of the Chilean Chemical Society*, 62(4): 3661-3667. [\[Crossref\]](#)
- Elosta, A., Ghous, T., & Ahmed, N. (2012). Natural products as anti-glycation agents: possible therapeutic potential for diabetic complications. *Current Diabetes Reviews*, 8(2), 92-108. [\[Crossref\]](#)
- Evans W.C., (2002) Trease and Evans. Pharmacognosy, 15th edition W.B. Saunders, Toronto, Harcourt Pub Ltd., pp 1-40.
- Ghallab, A. (2013). *In vitro* test systems and their limitations. *EXCLI journal*, 12, 1024–1026.
- Harborne J.B., (1998) Phytochemical Methods, A guide to Modern Techniques of Plant Analysis: Chapman and Hall. London, pp.49-185. [\[Crossref\]](#)
- Hussen, E. M., & Endalew, S. A. (2023). *In vitro* antioxidant and free-radical scavenging activities of polar leaf extracts of *Vernonia amygdalina*. *BMC Complementary Medicine and Therapies*, 23(1), 146. [\[Crossref\]](#)
- Inuwa, S. Z., Ndife, J., Bamalli, Z., Jibril, M. M., Tsoho Bala, H., & Zubairu, I. K. (2024). The Nutraceutical and Functional Food Potentials of Dry Doum Palm Fruit (*Hyphaene thebaica*). *UMYU Scientifica*, 3(1), 71–79. [\[Crossref\]](#)
- Isah, M., Olugbemi, P., Tomo, A., Farida, A., Muhammad, A. J., Bilyaminu, G., Salisu, B., & Sul'ain, M. D. (2025). From Lab to Market - A Critical Review of Pharmacological Properties , Bioavailability , Formulation , and Commercialization Challenges of *Cymbopogon citratus* (Lemongrass). *UMYU Scientifica*, 4(3), 367–380. [\[Crossref\]](#)
- Komolafe, I. J., Fajobi, A. O., Dare, C. A., Morakinyo, A. E., Adekola, M. B., Odekanyin, O. O., & Oyedapo, O. O. (2024). Antioxidant Potentials and Nephroprotective Effects of Methanol Extract and Dichloromethane Fraction of Root Bark of *Garcinia kola* (Heckel) on Gentamicin-Induced Nephrotoxic Rats. *UMYU Scientifica*, 3(4), 345–354. [\[Crossref\]](#)
- Kaewnarin, K., Niamsup, H., Shank, L., and Rakariyatham, N. (2014). Antioxidant and antiglycation activities of some edible and medicinal plants. *Chiang Mai Journal of Science*, 41(1):105-116. [\[Link\]](#)
- Kalemba, M. R. K., Makhuvele, R., & Njobeh, P. B. (2024). Phytochemical screening, antioxidant activity of selected methanolic plant extracts and their detoxification capabilities against AFB1 toxicity. *Heliyon* :10(2). [\[Crossref\]](#)
- Khalid, M., Petroianu, G., & Adem, A. (2022). Advanced glycation end products and diabetes mellitus: mechanisms and perspectives. *Biomolecules*, 12(4), 542. [\[Crossref\]](#)
- Lobo, V., Patil, A., Phatak, A., & Chandra, N. (2010). Free radicals, antioxidants and functional foods: Impact on human health. *Pharmacognosy Reviews*, 4(8), 118. [\[Crossref\]](#)
- Lokonon, B. E., Bonou, W. N., Kassa, B., Azihou, A. F., Assogbadjo, E., & Glelekakai, R. (2013). Structural and ethnobotanical characterization of velvet tamarind (*Dialium guineense* willd), a multipurpose tree species. *Agronomie Africaine*, 25(2), 121-131. [\[Crossref\]](#)
- Matsuura, N., Aradate, T., Sasaki, C., Kojima, H., Ohara, M., Hasegawa, J., and Ubukata, M. (2002). Screening system for the Maillard reaction inhibitor from natural product extracts. *Journal of Health Science*, 48(6): 520-526. [\[Crossref\]](#)
- Mohammed, J., Aremu, M. O., Abubakar, I., Kuna, H. U., & Mohammad, I. A. (2022). Evaluation of the Nutritive and Antioxidant Potentials of Velvet Tamarind (*Dialium guineense*) Seed, Pulp and Shell. *Chemical Science and Engineering Research*. 4(9), 14-18. [\[Crossref\]](#)
- Muhammad, I., Matazu, K. I., Kankia, I. H., Nasir, A., Yau, S., Shamsu, S., Suleiman, Z. A., Nasir, R., Sani, A. S., Lawal, R. G., Rawayau, M. A., Darma, I. S., Muhammad, A. N., Bahau'ddeen, S., Fardami, A. Y., & Matazu, H. K. (2024). Gastroprotective Effect of *Abelmoschus esculentus* (Ex-Maradi Okra Fruit Variety) Against Ethanol-Induced Ulcers in Rats. *UMYU Journal of Microbiology Research (UJMR)*, 9(3), 427–439. [\[Crossref\]](#)
- Muhammad, H. S., Atiku, M. K., Basheer, D. H., Zubairu, I. K., & Muhammad, S. M. (2024). Nutritional and Phytochemical Evaluation of Kanya (*Diospyros mespiliformis*) Juice: A Potential Functional Beverage for Enhanced Food Security. *UMYU Scientifica*, 3(2), 114–126. [\[Crossref\]](#)

- Muhammad, I., & Lawal, A. M. (2025). Base-assisted Extraction and GC-MS analysis of Bioactive Compounds from Mango and Neem Leaves: Potential for pharmaceutical and Bioenergy applications. *UMYU Scientifica*, 4(2), 387–395. [\[Crossref\]](#)
- Muhammad I., Matazu K. I., Kankia I. H., Nasir A., Yau' S., Shamsu S., Suleiman Z. A., Nasir R., Sani A. S., Lawal R. G., Rawayau M. A., Darma I. S., Muhammad A. N., Bahau'ddeen S., Fardami A. Y., & Matazu H. K. (2024). Gastroprotective Effect of *Abelmoschus esculentus* (Ex-Maradi Okra Fruit Variety) Against Ethanol-Induced Ulcers in Rats. *UMYU Journal of Microbiology Research (UJMR)*, 9(3), 427–439. [\[Crossref\]](#)
- Muhammad, I., Matazu, K. I., Nasir, A., Yau', S., Suleiman, Z. A., Kankia, H. I., Usman, B., Yaradua, A. I., Shamsu, S., Nasir, R., Aminu, G. B., Musa, T., Shamadeen, A. K., Sani, A. S., Lawal, R. G., Rawayau, M. A., Darma, I. S., Muhammad, A. N., Matazu, H. K., ... Bilbis, L. S. (2025). A Comprehensive in Vitro and in Vivo Evaluation of the Antioxidant and Antidiabetic Potential of an Okra (*Abelmoschus esculentus*) Nutraceutical Formulation. *UMYU Scientifica*, 4(4), 215–230. [\[Crossref\]](#)
- Musa, M. I., & Imam, T. S. (2022). Histopathological and Oxidative Stress Responses of the African Catfish *Clarias gariepinus* in Heavy Metal Contaminated Water from the Hadejia-Nguru. *UMYU Scientifica*, 1(2), 78–89. [\[Crossref\]](#)
- Nandhakumar, E., & Indumathi, P. (2013). In vitro antioxidant activities of methanol and aqueous extract of *Annona squamosa* (L.) fruit pulp. *Journal of Acupuncture and Meridian Studies*, 6(3), 142-148. [\[Crossref\]](#)
- Nasir, M. A., Ladan, M. J., Imam, A. U., & Mohammad, I. S. (2025). Solvent-Dependent Anticoagulant Effects of Combined Garlic (*Allium sativum*) and Roselle (*Hibiscus sabdariffa*) Extracts in Albino Rat Plasma. *UMYU Scientifica*, 4(4), 154–164. [\[Crossref\]](#)
- Ndu, C. F., Yilwa, V. M., Onwumere, G. B., Sunday, G. A., Appah, J., Enoch, E., Nwankwo, C. T., Daniel, D., & Pai, Y. Y. (2025). Comparative Analysis of Antioxidant Properties in Green and Reddish-Brown Leaves of *Terminalia catappa* Using DPPH and Nitric Oxide Assays. *UMYU Scientifica*, 4(2), 56–61. [\[Crossref\]](#)
- Nowotny, K., Schröter, D., Schreiner, M., & Grune, T. (2018). Dietary advanced glycation end products and their relevance for human health. *Ageing Research Reviews*, 47, 55-66. [\[Crossref\]](#)
- Ogu, G. I., Ezeadila, J., & Ehiobu, J. M. (2013). Antioxidant and antimicrobial activities of *Dialium guineense* (Willd) leaf extract. *Pharmacy and Pharmacology Research*, 1(1), 1-7. [\[Link\]](#)
- Oluwole-Banjo, A. K. (2019). Phytochemical and antioxidant properties of methanolic extracts of pulp, seed, leaf and stem bark of velvet tamarind (*Dialium guineense*) plant. *Journal of Underutilized Legumes*, 1(1), 159-168. [\[Link\]](#)
- Ovuakporie-Uvo, O., Idu, M. and Omoregie, E.S. (2019) Nutrients and chemical composition of *Desplatsia dewevrei*. *Food science and nutrition*, 7(5) : 1768-1777.
- Rao, A.V. and Gurfinkel, D.M. (2000) The Bioactivity of Saponins: Triterpenoid and Steroidal Glycosides" *Drug Metabolism and Drug Interactions*,17(1-4):211-236. [\[Crossref\]](#)
- Sadeghi, M., Miroliaei, M., Kamyabiamineh, A., Taslimi, P., & Ghanadian, M. (2023). The impact of AGEs on human health and the development of their inhibitors based on natural compounds. *Arabian Journal of Chemistry*, 16(10): 105143. [\[Crossref\]](#)
- Shah, N. A., Khan, M. R., Ahmad, B., Noureen, F., Rashid, U. and Khan, R. A. (2013). Investigation on flavonoid composition and anti-free radical potential of *Sida cordata*. *BMC Complementary and Alternative Medicine*. 13(1): 1-12. [\[Crossref\]](#)
- Silva, R. M., Martins, G. R., Nucci, L. M., Granero, F. O., Figueiredo, C. C., Santiago, P. S., & Silva, L. P. (2022). Antiglycation, antioxidant, antiacne, and photoprotective activities of crude extracts and triterpene saponin fraction of *Sapindus saponaria* L. fruits: An *in vitro* study. *Asian Pacific Journal of Tropical Biomedicine*, 12(9): 391-399. [\[Crossref\]](#)
- Tice, R. R., Austin, C. P., Kavlock, R. J., & Bucher, J. R. (2013). Improving the human hazard characterization of chemicals: a Tox21 update. *Environmental health perspectives*, 121(7), 756.
- Twarda-Clapa, A., Olczak, A., Bialkowska, A. M., & Koziolkiewicz, M. (2022). Advanced glycation end-products (AGEs): Formation, chemistry, classification, receptors, and diseases related to AGEs. *Cells*, 11(8), 1312. [\[Crossref\]](#)
- Usman H. S., Audu E., Umar U. A., Oguche E. J. and Sallau A. B. (2025b). Evaluation of advanced glycation end products and DPPH (1-diphenyl-2-picryl-hydrazyl) inhibitory potential of *Solanum macrocarpon* fruits and leaves: an *invitro* study. *Nigerian Journal of Biochemistry and Molecular Biology*. 40(2), 143-149 [\[Crossref\]](#)
- Usman, H. S., Audu, F., Umar, U.A., Garba, I. & Sallau, A. B. (2025a). *Solanum melongena* Fruits and Leaf Extracts can Inhibit Advanced Glycation End Products (AGEs) and 1-diphenyl-2-Picryl-hydrazyl (DPPH) Radical *In vitro*: A Preliminary Study. *Annals of Science and Technology - A*, 10 (1): 38-45. [\[Crossref\]](#)
- Usman, H. S., Musa, R., Usman, M. A., Hassan, S. M., Audu, F. E., & Sallau, A. B. (2023b). Effect of *Syzygium guineense* and *Borassus aethiopicum* leaves on protein glycation and oxidative stress suppression. *Nigerian Journal of Basic and Applied Sciences*, 31(1), 73-79. [\[Crossref\]](#)
- Usman, H. S., Uthman, I., Usman, M. A., Audu, F. E., Hassan, S. M., & Sallau, A. B. (2023a). The potential of *Diospyros mespiliformis* and *Carissa edulis* leaves towards inhibition of protein glycation and oxidative stress. *Nigerian Journal of Biochemistry and Molecular Biology*, 38(2): 94-99. [\[Link\]](#)

- Utubaku, A.B., Yakubu, O.E. and Okwara, D.U. (2017) Comparative Phytochemical Analysis of Fermented and Unfermented Seeds of *Dialium guineense*. *Journal of Traditional Medicine and Clinical Naturopathy*; 6(3): 226-228. [\[Crossref\]](#)
- Zawada, A., Machowiak, A., Rychter, A. M., Ratajczak, A. E., Szymczak-Tomczak, A., Dobrowolska, A., & Krela-Każmierczak, I. (2022). Accumulation of advanced glycation end-products in the body and dietary habits. *Nutrients*, 14(19), 3982. [\[Crossref\]](#)