**Evaluation of Bioactive Compounds and Anti-Hyperlipidemic Potential of Hog Plum (*Spondias* *mombin*) with Implications for Functional Food Development**

**Abstract**

*Spondias* *mombin*, commonly known as hog plum, has been traditionally used in folk medicine for the treatment of various ailments. This study evaluates the phytochemical composition, antioxidant activity, and anti-hyperlipidemic potential of *S. mombin* extract using both in-vitro and in-vivo models. Quantitative phytochemical analysis revealed high concentrations of tannins (57.50 ± 0.01 mg AAE/g), saponins (40.02 ± 0.00 mg/100g), and flavonoids (40.34 ± 0.02 mg RE/g). GC-MS profiling identified key bioactive constituents including 9-Octadecenoic acid (Z)-, 2,3-dihydroxypropyl ester (15.32%), Octadecane, 1-chloro- (3.21%), and 9,12-Octadecadienoic acid (Z,Z) (3.92%). In-vivo administration of *S. mombin* extract at a dose of 200 mg/kg significantly reduced total cholesterol (8.6%), triglycerides (8.2%), and LDL (40.4%) levels, while increasing HDL (49.4%) and improving atherogenic indices (AC by 59.8%) in poloxamer 407-induced hyperlipidemic rats. Antioxidant assays showed a 73.1% decrease in lipid peroxidation and a 151.6% increase in superoxide dismutase (SOD) activity. These findings suggest that *S. mombin* possesses significant lipid-lowering and antioxidant properties, making it a promising candidate for incorporation into functional foods targeting cardiovascular health. This study supports the traditional use of *S. mombin* and highlights its potential as a natural therapeutic agent for managing hyperlipidemia through dietary interventions.

**Keywords:** *Spondias* *mombin*, Hyperlipidemia, Functional Foods, Phytochemicals, Lipid Metabolism, Antioxidants

**Introduction**

Cardiovascular diseases driven by hyperlipidemia remain a leading cause of global morbidity and mortality (Achila et al., 2021). Despite advances in pharmacotherapy, challenges such as drug resistance, adverse effects, and patient non-compliance necessitate the exploration of alternative or complementary strategies (Valentino et al., 2020). Natural products, particularly those derived from plants, have gained considerable attention due to their diverse bioactive profiles and relatively low toxicity (Lonardo et al., 2020). Among these, *Spondias mombin* (Anacardiaceae), a tropical fruit tree widely distributed across Africa and South America, has long been utilized in traditional medicine for treating conditions ranging from inflammation to metabolic disorders (Almeida et al., 2024). Its ethnobotanical relevance, coupled with emerging scientific evidence, positions *S. mombin* as a promising candidate for the development of functional foods aimed at managing dyslipidemia (Swathi & Lakshman, 2022).

Hyperlipidemia, characterized by elevated levels of serum lipids such as cholesterol and triglycerides, contributes significantly to the progression of atherosclerosis and coronary heart disease (El-Tantawy & Temraz, 2019). The condition is often associated with lifestyle factors including poor diet, physical inactivity, and genetic predisposition (Alam et al., 2022). Conventional therapies, primarily statins and fibrates, are effective but may be accompanied by side effects such as myopathy, liver dysfunction, and gastrointestinal disturbances (Lucena et al., 2022). As such, there is growing interest in identifying plant-based alternatives that can modulate lipid metabolism safely and effectively (Konstantinidi & Koutelidakis, 2019). Several studies have demonstrated the hypolipidemic effects of natural compounds through mechanisms such as enzyme inhibition, increased fecal excretion of bile acids, and enhanced antioxidant defense systems (Jędrusek-Golińska et al., 2020).

Phytochemical investigations of *S. mombin* have revealed a rich array of secondary metabolites, including polyphenols, flavonoids, saponins, and phytosterols—compounds well-documented for their cardioprotective effects (Akwu et al., 2024). For instance, flavonoids exert antioxidant activity by scavenging free radicals and inhibiting lipid peroxidation, while saponins reduce intestinal cholesterol absorption by forming insoluble complexes with bile salts (Akinlolu-Ojo et al., 2022). Phytosterols, structurally similar to cholesterol, compete with its absorption in the gut, thereby lowering circulating lipid levels (Sinan et al., 2021). Additionally, fatty acid derivatives like 9-Octadecenoic acid and 9,12-Octadecadienoic acid, identified in this study via GC-MS, have shown promise in regulating lipid homeostasis (Venkatakrishnan et al., 2019). However, despite the documented biological activities of these compounds in other contexts, the specific impact of *S. mombin* extracts on lipid metabolism remains underexplored (Asgary et al., 2018).

Several in vitro and in vivo studies have highlighted the anti-inflammatory, antimicrobial, and antidiabetic potentials of *S. mombin* (Almeida et al., 2024). However, systematic investigations into its role in lipid regulation are limited (Plabon et al., 2021). One notable gap lies in the lack of standardized protocols for evaluating the efficacy of *S. mombin* extracts in experimental models of hyperlipidemia (Nie & Luo, 2021). While preliminary studies have suggested beneficial effects on lipid profiles, comprehensive assessments involving biochemical parameters, enzymatic activity, and antioxidant status are lacking (Malik et al., 2023). Furthermore, the integration of traditional knowledge with modern pharmacological approaches offers a unique opportunity to validate and harness the therapeutic potential of this plant for preventive healthcare (Samarghandian et al., 2013).

The present study aims to bridge these gaps by evaluating the anti-hyperlipidemic and antioxidant properties of *S. mombin* extract using a combination of phytochemical analysis, in-vitro assays, and an in-vivo model of hyperlipidemia induced by poloxamer 407. We also assess the feasibility of incorporating the extract into functional food formulations, considering its bioactive profile and observed physiological effects. By focusing on the lipid-lowering capacity of *S. mombin* and its underlying mechanisms, this research contributes to the growing body of evidence supporting the use of plant-based interventions in the management of cardiovascular risk factors (Cristofoli et al., 2019).

**Materials and Methods**

***Plant Sample Collection and Identification***

Fresh leaves of *Spondias* *mombin* were collected from Fiidi Council Ward, Makurdi, Benue State, Nigeria. The plant was authenticated by a taxonomist, at Federal University of Lafia, Nasarawa State, Nigeria, and a voucher specimen was deposited in the university’s herbarium for future reference (Akwu et al., 2024).

***Crude Extract Preparation***

The leaves was separated, shade-dried, and ground into a fine powder. A total of 200 g of the powdered sample was macerated in 70% ethanol (1 L) for 48 hours with intermittent shaking. The resulting filtrate was filtered using Whatman No. 1 filter paper and concentrated under reduced pressure using a rotary evaporator. The semi-solid extract was further lyophilized to obtain a dry residue and stored at 4°C for subsequent analyses (Karam et al., 2016).

**Phytochemical Analysis**

***Qualitative Phytochemical Screening***

Preliminary qualitative phytochemical screening was carried out to detect the presence of alkaloids, flavonoids, saponins, tannins, terpenoids, and phenolic compounds using standard protocols. Mayer’s test was used for alkaloid detection, while the ferric chloride test was employed for phenolic compounds based on color change to dark green, blue, or purple (Darshan, 2019).

***Quantitative Phytochemical Analysis***

Quantitative estimation of bioactive constituents was performed as follows:

**Total Phenolic Content (TPC):** Determined using the Folin-Ciocalteau method and expressed as mg Gallic Acid Equivalent (GAE)/g.

**Total Flavonoid Content (TFC):** Estimated via aluminum chloride colorimetry and expressed as mg Rutin Equivalent (RE)/g.

**Total Tannin Content:** Quantified using the method described by Makkar et al., expressed as mg Ascorbic Acid Equivalent (AAE)/g.

**Total Saponin Content:** Gravimetrically determined after extraction with diethyl ether and expressed as mg/100g.

**Total Alkaloid Content:** Measured using the method of Harborne, expressed as mg/100g.

All determinations were carried out in triplicate to ensure reproducibility and accuracy (Ohiri et al., 2023).

**Gas Chromatography-Mass Spectrometry (GC-MS) Profiling**

The *Spondias mombin* extract was subjected to GC-MS analysis to identify volatile and semi-volatile bioactive compounds. Sample preparation involved dissolving the dried extract in ethyl acetate followed by filtration through a 0.45 µm syringe filter. The filtrate was then concentrated and used for injection. GC-MS analysis was conducted using an Agilent Technologies system (Model No. 19091S-933), equipped with an HP-1 capillary column (0.25 mm × 30 m × 0.25 μm film thickness). The oven temperature was programmed from 50°C to 300°C at a rate of 5°C/min. Helium was used as the carrier gas at a constant flow rate of 1 mL/min. Mass spectra were recorded in electron ionization mode, and compounds were identified by comparing retention indices and mass spectral data against the NIST library (version 2020). The major bioactive compounds identified included 9-Octadecenoic acid (Z)-, 2,3-dihydroxypropyl ester (15.32%), Octadecane, 1-chloro- (3.21%), and 9,12-Octadecadienoic acid (Z,Z) (3.92%) (Naibaho et al., 2021).

**Biochemical Studies**

***In-Vivo Anti-Hyperlipidemic Assessment***

A poloxamer 407-induced hyperlipidemic rat model was used to evaluate the lipid-lowering effects of *Spondias* *mombin* extract. Thirty male Wistar rats were divided into five groups:

1. Normal control group

2. Hyperlipidemic control group (induced with 1 g/kg body weight of poloxamer 407)

3. Standard drug group (atorvastatin, 10 mg/kg)

4. Test group I (extract, 100 mg/kg)

5. Test group II (extract, 200 mg/kg)

Following a 7-day treatment period, blood samples were collected for biochemical analysis (Adefegha, 2018).

***Serum Lipid Profile Determination***

1. ***Total Cholesterol (TC):*** Measured using the cholesterol oxidase-peroxidase (CHOD-PAP) method.
2. ***Triglycerides (TG):*** Determined via the glycerol phosphate oxidase-peroxidase (GPO-PAP) method.
3. ***High-Density Lipoprotein Cholesterol (HDL-C):*** Precipitated using phosphotungstic acid and magnesium chloride before measurement.
4. ***Low-Density Lipoprotein Cholesterol (LDL-C):*** Calculated using Friedewald’s formula: LDL-C = TC – HDL-C – (TG/5).
5. ***Very Low-Density Lipoprotein Cholesterol (VLDL-C):*** Derived from TG levels using the relation VLDL-C = TG/5.

Cardiovascular risk indices including Atherogenic Index (AI), Cardiac Risk Ratio (CRR), and Atherogenic Coefficient (AC) were calculated from the lipid parameters (El-Tantawy & Temraz, 2019).

***Oxidative Stress Marker Evaluation***

1. ***Thiobarbituric Acid Reactive Substances (TBARS):*** Used to quantify lipid peroxidation as malondialdehyde (MDA) equivalents.
2. ***Superoxide Dismutase (SOD):*** Assayed spectrophotometrically using the nitroblue tetrazolium (NBT) reduction method.
3. ***Reduced Glutathione (GSH):*** Estimated using Ellman’s reagent.
4. ***Glutathione Peroxidase (GPx):*** Measured based on the oxidation of GSH coupled with the activity of glutathione reductase.

All assays were performed using commercially available diagnostic kits following manufacturer instructions (Buchtova et al., 2018; Darshan, 2019).

**Statistical Analysis**

All experimental data were expressed as mean ± standard deviation (SD). Statistical comparisons between groups were performed using one-way ANOVA followed by Tukey’s post hoc test for multiple comparisons. Pearson’s correlation coefficient was used to assess relationships between variables where applicable. Statistical significance was set at p < 0.05. Analyses were conducted using SPSS version 26 (IBM Corp.) and GraphPad Prism v9 (Munekata et al., 2021).

**4.1 Results**

**Table 1:** **Quantitative Phytochemical Analysis**

|  |  |
| --- | --- |
| **Phytochemical** | **Mean ± Standard Deviation (SD)** |
| Total Phenol (mg GAE/g) | 8.33 ± 0.55 |
| Total Saponin (mg/100g) | 40.02 ± 0.00 |
| Total Tannin (mg AAE/g) | 57.50 ± 0.01 |
| Total Flavonoid (mg RE/g) | 40.34 ± 0.02 |
| Total Alkaloids (mg/100g) | 44.97 ± 0.03 |



**Figure 1: *Spondias mombin* GC-MS Chromatogram**

**Table 2: GC-MS of *Spondias mombin* Bioactive Compounds**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Peak**  | **RT** | **Compound Detected** | **Mol. Formula** | **MW** | **Peak Area %** | **Comp** **%wt** | **m/z** | **Structures** |
| 1 | 3.21 | 1-Butanol, 3-methyl- | C5H12O | 88 | 0.32 | 1.02 | 42, 55, 88 | C5H12O |
| 2 | 6.00 | 1-Hexanol, 2-ethyl- | C8H18O | 130 | 1.27 | 1.73 | 41, 57, 130 | C8H18O |
| 3 | 6.50 | Carbamic acid, phenyl ester | C7H7NO2 | 137 | 1.91 | 2.52 | 43, 94, 137 | C7H7NO2 |
| 4 | 7.21 | Xylitol | C5H12O5 | 152 | 0.96 | 1.21 | 43, 61, 152 | C5H12O5 |
| 5 | 8.50 | 2-Methoxy-4-vinylphenol | C9H10O2 | 150 | 0.80 | 1.04 | 77, 135, 150 | C9H10O2 |
| 6 | 9.28 | 1-Cyclohexene-1-carboxaldehyde, 2,6,6-trimethyl- | C10H16O | 152 | 0.38 | 0.92 | 41, 87, 152 | C10H16O |
| 7 | 14.25 | Tridecane | C13H28 | 184 | 1.34 | 1.60 | 43, 57, 184 | C13H28 |
| 8 | 15.50 | Piperazine, 1-(2-methoxyphenyl)-4-acetyl | C13H18N2O2 | 234 | 1.46 | 1.54 | 43, 57, 234 | C13H18N2O2 |
| 9 | 17.50 | Methyl 4-(3-oxocyclohexyl)butanoate | [C11H18O3](https://pubchem.ncbi.nlm.nih.gov#query=C11H18O3) | 198 | 0.48 | 1.07 | 41, 97, 198 | Methyl 4-(3-oxocyclohexyl)butanoate.png |
| 10 | 18.75 | n-Hexadecanoic acid | C16H32O2 | 256 | 14.33 | 15.42 | 43, 73, 256 | C16H32O2 |
| 11 | 20.75 | 1,4-Bis(trimethylsilyl)benzene | C12H22Si2 | 222 | 3.18 | 2.42 | 73, 207, 222 | C12H22Si2 |
| 12 | 22.00 | 10-Methyl-E-11-tridecen-1-ol propionate | [C17H32O2](https://pubchem.ncbi.nlm.nih.gov#query=C17H32O2) | 268 | 2.23 | 1.75 | 41, 57, 268 | 10-Methyl-E-11-tridecen-1-ol propionate.png |
| 13 | 24.00 | 9,12-Octadecadienoic acid (Z,Z)- | C18H32O2 | 280 | 1.40 | 3.92 | 41, 67, 280 | C18H32O2 |
| 14 | 25.00 | Hexadecanoic acid, methyl ester | C17H34O2 | 270 | 1.59 | 2.87 | 43, 74, 270 | C17H34O2 |
| 15 | 30.50 | Octadecane, 1-chloro- | C18H37Cl | 288 | 4.46 | 3.21 | 43, 57, 288 | C18H37Cl |
| 16 | 32.53 | Octadecanoic acid | C18H36O2 | 284 | 10.19 | 11.00 | 43, 73, 284 | C18H36O2 |
| 17 | 33.98 | Oleic acid | C18H34O2 | 282 | 12.74 | 9.56 | 41, 55, 282 | C18H34O2 |
| 18 | 34.50 | Phytol | C20H40O | 296 | 2.55 | 3.21 | 43, 71, 296 | C20H40O |
| 19 | 35.00 | 9-Octadecenoic acid (Z)-, 2,3-dihydroxypropyl ester | C21H40O4 | 356 | 13.38 | 15.32 | 43, 55, 356 | C21H40O4 |
| 20 | 35.97 | Campesterol | C28H48O | 400 | 5.10 | 6.41 | 43, 55, 400 | C28H48O |
| 21 | 37.00 | Stigmasterol | C29H48O | 412 | 1.15 | 2.37 | 43, 55, 412 | C29H48O |
| 22 | 38.75 | γ-Tocopherol | C28H48O2 | 416 | 14.65 | 5.73 | 43, 151, 416 | C28H48O2 |
| 23 | 42.75 | α-Tocopheryl acetate | C31H52O3 | 472 | 1.37 | 2.06 | 43, 185, 472 | C31H52O3 |
| 24 | 43.61 | L-Ascorbic acid, dihexadecanoate | [C38H68O8](https://pubchem.ncbi.nlm.nih.gov#query=C38H68O8) | 652 | 1.82 | 2.10 | 41, 77,652 | L-Ascorbic acid, dihexadecanoate.png |

**Figure 2:** Effect of *Spondias* *mombin* (SM) Extract on Lipid Profile Parameters - Total Cholesterol (TC, mg/dL), and Triacylglycerol (TAG, mg/dL)

**Figure 3:** Effect of *Spondias* *mombin* (SM) extract on lipid profile parameters - HDL (mg/dL), LDL (mg/dL) and VLDL (mg/dL)

**Figure 4:** Effects of *Spondias* *mombin* (SM) extract on cardiovascular risk indices

**Figure 5:** Effects of *Spondias* *mombin* (SM) extract on oxidative stress markers parameters – SOD and GPx

**Figure 6:** Effects of *Spondias* *mombin* (SM) extract on oxidative stress markers parameters – TBARS

**Figure 7:** Effects of *Spondias* *mombin* (SM) extract on oxidative stress markers parameters – GSH

**Discussion**

The present study provides compelling evidence for the anti-hyperlipidemic and antioxidant potential of *Spondias mombin* (hog plum) extract in a poloxamer 407-induced hyperlipidemic rat model. These findings support the traditional use of this plant in managing metabolic disorders and highlight its relevance in functional food development. The observed lipid-lowering effects can be attributed to the synergistic action of bioactive compounds such as tannins, saponins, flavonoids, and fatty acid derivatives identified through phytochemical and GC-MS analyses.

From Table 1, Phytochemical screening revealed high concentrations of tannins (57.50 ± 0.01 mg AAE/g), saponins (40.02 ± 0.00 mg/100g), and flavonoids (40.34 ± 0.02 mg RE/g), consistent with previous reports indicating the presence of these secondary metabolites in *Spondias* species (Akwu et al., 2024; Sameh et al., 2018). These compounds are well-documented for their hypocholesterolemic and antioxidant properties. For instance, saponins may reduce intestinal cholesterol absorption by forming micellar complexes with bile acids, thereby promoting fecal excretion of cholesterol metabolites. Flavonoids exert potent antioxidant activity by scavenging reactive oxygen species and inhibiting lipid peroxidation, which is crucial in preventing oxidative stress-mediated endothelial dysfunction and atherosclerosis.

GC-MS profiling further identified key bioactive constituents, including 9-Octadecenoic acid (Z)-, 2,3-dihydroxypropyl ester (15.32%), Octadecane, 1-chloro- (3.21%), and 9,12-Octadecadienoic acid (Z,Z) (3.92%) as observed in Figure 1 and Table 2. These compounds have previously been associated with anti-inflammatory, antithrombotic, and lipid-regulating effects (Naibaho et al., 2021; Venkatakrishnan et al., 2019). Their presence supports the observed biochemical improvements in lipid profiles and antioxidant enzyme activities in hyperlipidemic rats treated with the extract |following the observation expressed in Figure 2-7.

Administration of *Spondias mombin* extract at doses of 100 and 200 mg/kg significantly improved lipid parameters in poloxamer 407-induced hyperlipidemic rats. Specifically, total cholesterol and triglycerides (Figure 2) were reduced, while HDL-C levels increased (Figure 3), leading to favorable alterations in atherogenic indices such as the atherogenic coefficient (AC) and cardiac risk ratio (CRR) (Figure 4). These findings align with earlier studies that demonstrated similar lipid-lowering effects using plant extracts rich in polyphenolic and triterpenoid compounds (Sandner et al., 2020; Bahr et al., 2021).

Oxidative stress markers also showed marked improvement following treatment. Lipid peroxidation was significantly decreased, while superoxide dismutase (SOD) activity increased by over 150%, suggesting enhanced endogenous antioxidant defense mechanisms as revealed in Figure 5. This effect may contribute to the overall cardioprotective benefits of the extract, as oxidative stress plays a pivotal role in the pathogenesis of cardiovascular diseases

Notably, the absence of adverse effects in preliminary safety assessments indicates that the extract can be administered at the tested doses without significant toxicity concerns. This observation is consistent with previous studies that reported no observable behavioral or physiological changes in animals treated with *Spondias* extracts (Bukunmi Ogunro, 2023). However, further sub-chronic and chronic toxicity studies are recommended before advancing to clinical trials.

The results support the integration of *Spondias mombin* into functional food formulations due to its multi-targeted mechanism of action and natural origin. Incorporating the extract into food matrices such as fortified beverages, nutraceutical bars, or encapsulated delivery systems could enhance consumer compliance and provide long-term cardiovascular benefits. Moreover, its lipid-lowering and antioxidant properties align with the concept of functional foods aimed at disease prevention rather than merely nutritional supplementation (Granato et al., 2017; Russo et al., 2021).

*Spondias* *mombin*’s high tannin levels (Table 1) also make it a candidate for natural preservatives in food industries, where tannins inhibit lipid oxidation and microbial spoilage (Ohiri et al., 2023). This dual functionality—both as a therapeutic agent and a food preservative—enhances its commercial viability in the development of value-added functional products.

Furthermore, the observed dose-dependent response suggests that careful titration of the extract is necessary to maximize efficacy. Although higher doses (e.g., 400 mg/kg) were employed, highlighting the need for optimal dosing strategies. This is particularly important for translational applications, especially if the extract is intended for long-term consumption as part of dietary interventions.

The experimental model used in this study—poloxamer 407-induced hyperlipidemia—is a well-established method for evaluating acute lipid elevation and testing hypolipidemic agents (Samarghandian et al., 2013). Blood samples were collected via cardiac puncture and analyzed using a Cardio Check device (Mission Cholesterol Meter, model CCM-111, Germany), with atorvastatin serving as the reference drug. The consistency of lipid profile trends across replicate groups strengthens the reliability of the observed outcomes.

Importantly, the current findings corroborate existing literature on the genus *Spondias*, which has been shown to possess diverse pharmacological activities, including antimicrobial, anti-inflammatory, and antidiabetic effects (Moke et al., 2024; Mondal et al., 2021). The addition of lipid-modulating activity broadens its therapeutic spectrum and underscores its importance in integrative health approaches.

From a public health perspective, the increasing global burden of non-communicable diseases, particularly cardiovascular conditions, necessitates innovative and accessible solutions. Functional foods enriched with plant-based bioactives offer a sustainable and preventive approach to managing dyslipidemia and reducing the risk of associated complications. The Mediterranean diet, for example, emphasizes the inclusion of natural antioxidants and lipid-lowering foods, aligning closely with the principles underlying this research (Russo et al., 2021). This study confirms the anti-hyperlipidemic and antioxidant efficacy of *Spondias mombin* extract in an experimental model of hyperlipidemia. The findings validate the ethnopharmacological use of this plant and underscore its potential as a functional food ingredient. Future research should focus on formulation development, sensory evaluation, and human clinical trials to establish its efficacy and safety in target populations.

**Conclusion**

The present study demonstrates that *Spondias mombin* (hog plum) extract exhibits significant anti-hyperlipidemic and antioxidant activity in a poloxamer 407-induced hyperlipidemic rat model. The phytochemical profile revealed high concentrations of tannins (57.50 ± 0.01 mg AAE/g), saponins (40.02 ± 0.00 mg/100g), flavonoids (40.34 ± 0.02 mg RE/g), and alkaloids (44.97 ± 0.03 mg/100g), which are well-documented for their lipid-lowering and antioxidant properties. GC-MS profiling identified several bioactive compounds, including γ-tocopherol (14.65%), stigmasterol (1.15%), and α-tocopheryl acetate (1.37%), which have been previously associated with anti-inflammatory, antithrombotic, and cholesterol-regulating effects. These findings suggest that the observed biological activities may be attributed to the synergistic action of these bioactive constituents.

Administration of *Spondias mombin* extract at doses of 200 and 400 mg/kg body weight significantly improved lipid profiles in hyperlipidemic rats. Total cholesterol (TC) and triglycerides (TAG) were reduced, while HDL-C levels increased, leading to favorable modifications in atherogenic indices such as the atherogenic coefficient (AC) and cardiac risk index (CRI). Oxidative stress markers also showed improvement, with a notable decrease in TBARS levels and an increase in SOD and GPx activities, indicating enhanced endogenous antioxidant defense mechanisms. These results align with previous studies showing similar lipid-lowering effects using plant extracts rich in polyphenolic and triterpenoid compounds (Lucena et al., 2022; Malik et al., 2023), reinforcing the therapeutic potential of *Spondias mombin* in managing dyslipidemia.

The observed effects support the traditional use of *Spondias mombin* in managing metabolic disorders and underscore its relevance in functional food development. Its multi-targeted mechanism of action, coupled with natural origin and absence of observable toxicity in preliminary assessments, makes it a promising candidate for incorporation into nutraceuticals or functional foods aimed at preventing or managing cardiovascular diseases. Future studies should focus on optimizing formulation strategies for stability and bioavailability, conducting sensory evaluation, and advancing to human clinical trials to validate these findings in target populations. Sub-chronic and chronic toxicity studies are also recommended to ensure long-term safety before commercial application.

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