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Phytochemical and antioxidant potential of *Adansonia digitata* L. Fruit Pulp

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Abstract:

The present study explored the phytochemical composition and antioxidant potential of *Adansonia digitata* L. fruit pulp, emphasizing its role as a functional food with immunomodulatory benefits. Phytochemical screening confirmed the presence of flavonoids, tannins, saponins, and terpenoids, which contributed to their biological activity. Quantitative analysis revealed a high concentration of phenolics (127.23 ± 0.99 mg GAE/g), flavonoids (80.12 ± 1.44 mg RE/g), and tannins (165.47 ± 1.11 mg TAE/g), signifying its strong antioxidant and anti-inflammatory properties. The DPPH radical scavenging assay demonstrated moderate antioxidant activity, with an IC_{50} value of 53.85 µg/mL, whereas the nitric oxide (NO) scavenging assay indicated potent inhibition of reactive nitrogen species (IC_{50} = 40.03 µg/mL). These findings highlight the ability of *A. digitata* fruit pulp to mitigate oxidative stress, supporting its traditional application in managing infections and inflammatory disorders. The high phenolic and flavonoid content suggests a potential role in immune modulation, metabolic regulation, and disease prevention. Given the increasing prevalence of oxidative stress-mediated diseases, including immune dysfunction, diabetes, and cardiovascular disorders, *A. digitata* fruit pulp is a promising natural dietary intervention. This study reinforces its potential application in nutraceutical and functional food formulations aimed at enhancing immune resilience. Further *in vivo* and clinical investigations are required to elucidate immunomodulatory mechanisms and validate its therapeutic efficacy in human health.

Keywords **— *Adansonia digitata*, phytochemicals, antioxidant activity, immune modulation, oxidative stress, functional food**

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I. INTRODUCTION

Oxidative stress plays a crucial role in immune disorders by disrupting the balance between reactive oxygen species (ROS) and the body's antioxidant defenses, leading to cellular damage and immune dysfunction [1]. This imbalance is evident in autoimmune diseases, such as rheumatoid arthritis, systemic lupus erythematosus, and Hashimoto's thyroiditis, where elevated oxidative stress markers and inflammatory cytokines contribute to chronic inflammation and disease severity [2]. Similarly, in critically ill patients, oxidative stress exacerbates immune dysregulation and organ dysfunction, thereby creating a harmful cycle of inflammation and oxidative damage. Autism spectrum disorders (ASDs) also show a strong link between oxidative stress and immune dysfunction, with genetic alterations affecting ROS-scavenging mechanisms that influence disease progression [3-4]. Emerging therapeutic strategies, including antioxidant therapies and oxidative stress biomarkers, are being explored to restore immune balance and mitigate disease progression [5]. Understanding the interplay between oxidative stress and immune function

could lead to innovative treatments and improve patient outcomes for these complex disorders. Further research is required to develop targeted interventions for more effective disease management [6-7].

Adansonia digitata L., commonly known as the baobab tree, is a nutritionally and pharmacologically rich plant with immense therapeutic potential [8]. Traditionally used in African and tropical medicine, its fruit pulp contains vitamin C, polyphenols, flavonoids, and tannins, contributing to its remarkable antioxidant activity [9]. These bioactive compounds not only scavenge free radicals but also mitigate oxidative stress, a key factor in chronic diseases [10]. In addition to its antioxidant properties, *A. digitata* exhibits antimicrobial, antiviral, hypoglycemic, and hypolipidemic effects, making it a promising candidate for metabolic and immune health [11]. The high fiber content of fruit pulp supports gut microbiota balance, while its phytochemicals regulate glucose absorption and lipid metabolism, demonstrating potential for diabetes and cardiovascular disease management [12]. Despite its well-documented benefits, few studies have explored its direct immunomodulatory role. This study aimed to bridge this gap by evaluating the phytochemical composition and antioxidant potential of *A. digitata*, providing scientific validation for its use as a functional food for immune resilience and disease prevention [13].

II. MATERIALS AND METHODS

2.1. Plant material

Adansonia digitata L. was collected from Nampally, Telangana, and authenticated by the Botanical Survey of India (BSI/DRC/2023-24/Identification/52), Deccan Region, Hyderabad, India.

2.2. Extraction

The fruits were collected and the pulp was manually separated. Phytochemicals from the dried fruit pulp powder were extracted by Soxhlet extraction using ethanol at 60^0C for 24 h. The crude extract was collected, filtered, and the solvent evaporated using a rotary evaporator at 40^0C [14].

2.3. Phytochemical study

Preliminary phytochemical analysis of the *A. digitata* extract was performed according to previously established protocols [15].

2.4. Quantitative Phytochemical Screening

2.4.1. Determination of Total Phenolic Content

The total phenolic content of the sample was determined using the Folin-Ciocalteu method with gallic acid as the standard. Approximately 0.5 mL of the extract was mixed with Folin-Ciocalteu reagent (0.5 mL) and allowed to react for 5 min. Subsequently this, 2.5 mL of 7% sodium carbonate solution was added, and the reaction mixture was diluted to 25 mL with distilled water. The solution was incubated at room temperature for 90 min and the absorbance was measured at 550 nm using a UV-visible spectrophotometer. A standard calibration curve of gallic acid (200–1000 µg/mL) was used for quantification. The results are expressed as mg gallic acid equivalent (GAE) per g of extract [16].

2.4.2. Determination of Total Flavonoid Content

The total flavonoid content was determined using an aluminum chloride colorimetric assay with rutin as the standard. In a 10 mL volumetric flask, 1 mL of the extract was mixed with 4 mL of distilled water. After 5 minutes, 0.3 mL of 5% sodium nitrite solution was added, followed by 0.3 mL of 10% aluminum chloride solution after another 5 min. After 6 min, 2 mL of 1 M sodium hydroxide was added, and the volume was made up to 10 mL using distilled water. The solution was incubated at room temperature for 30 min and the absorbance was recorded at 510 nm using a UV-visible spectrophotometer. A standard curve of rutin (100–1000 µg/mL) was used to determine the flavonoid content, which was expressed as mg rutin equivalent (RE) per gram of extract [17-19].

2.4.3. Determination of Total Tannin Content

The total tannin content was analyzed using the vanillin-hydrochloric acid (HCl) method, with tannic acid as the standard. A 400 µL aliquot of the diluted extract was mixed with 3 mL of 4% methanol vanillin solution and concentrated HCl (1.5 mL of concentrated HCl. The mixture was then incubated at room temperature for 15 min. Absorbance was measured at 500 nm using a UV-visible spectrophotometer. The tannin content was expressed as milligram tannic acid equivalent per

gram of extract using a standard calibration curve [20-21]

2.4.4. Antioxidant activity

2.4.4.1. DPPH Free Radical Scavenging Assay

The antioxidant activity of the extract was evaluated using a DPPH (2,2-diphenyl-1-picrylhydrazyl) free radical scavenging assay. A 1 mL aliquot of the extract was mixed with 3 mL of 0.5 mM DPPH solution prepared in methanol. The reaction mixture was then incubated in the dark at room temperature for 30 min. Absorbance was measured at 517 nm using a UV-visible spectrophotometer [22-23]. The percent inhibition of DPPH radicals was calculated using the following equation:

$$\% \text{ Inhibition} = [(A_{control} - A_{sample})/ A_{control}] \times 100$$

Ascorbic acid was used as a positive control, and IC_{50} values were determined

2.4.4.2. Nitric Oxide (NO) Free Radical Scavenging Assay

The nitric oxide (NO) scavenging activity of the extract was determined using sodium nitroprusside as the NO donor. The reaction mixture contained 1 mL of sodium nitroprusside solution (10 mM) in phosphate-buffered saline (pH 7.4) and 1 mL of the extract at different concentrations. The mixture was then incubated at 25°C for 150 min. After incubation, 1 mL Griess reagent (1% sulfanilamide and 0.1% naphthyl ethylenediamine dihydrochloride in 2% phosphoric acid) was added to 1 mL of the reaction mixture. The absorbance was measured at 546 nm using a UV-visible spectrophotometer. The percentage of inhibition of NO radicals was calculated using the equation described for the DPPH assay. Ascorbic acid was used as the standard [24].

3. RESULTS

3.1. Phytochemical screening

Preliminary phytochemical analysis of the ethanolic extract of *A. digitata* fruit pulp revealed several secondary metabolites, including alkaloids, saponins, flavonoids, and tannins (Table 1).

Table 1. Phytochemical profile of *A. digitata*

Phytochemicals	Ethanol extract
Alkaloids	-
Glycosides	+
Saponins	+
Flavonoids	+
Steroids	+
Tannins	+

Present (+)/absent (-)

3.2. Quantitative Phytochemical Screening

3.2.1. Total Phenolic content

The total phenolic content (TPC) of *Adansonia digitata* fruit pulp was determined to be 127.23 ± 0.99 mg GAE/g, indicating a substantial presence of phenolic compounds. Phenolics are known for their strong antioxidant properties as they can neutralize free radicals and inhibit oxidative damage. This high TPC value suggests that *A. digitata* fruit pulp is a potent source of bioactive compounds that contribute to its pharmacological effects, particularly in mitigating oxidative stress-related disorders. The presence of phenolics in significant amounts aligns with previous reports, highlighting the role of baobab pulp in protecting against cellular damage, inflammation, and metabolic dysregulation.

3.2.2. Total Flavonoid content

The total flavonoid content (TFC) of *A. digitata* fruit pulp was recorded as 80.12 ± 1.44 mg RE/g, demonstrating a notable concentration of flavonoids, which are key secondary metabolites with immunomodulatory, anti-inflammatory, and antimicrobial properties. Flavonoids play a critical role in enhancing immune function by modulating cytokine release, reducing oxidative stress, and strengthening cellular defence mechanisms. The relatively high TFC value indicates that baobab pulp may contribute to immune resilience and metabolic homeostasis. The presence of these bioactive compounds supports the traditional use of baobab for treating infections and inflammatory disorders, reinforcing its functional potential in nutraceutical applications.

3.2.3. Total Tannin content

The total tannin content (TTC) of *A. digitata* fruit pulp was 165.47 ± 1.11 mg TAE/g, suggesting a significant presence of tannins, which are known for their antimicrobial, astringent, and

gastroprotective properties. Tannins have been reported to inhibit microbial growth, regulate digestive enzyme activity, and contribute to gut health, thus making baobab pulp a valuable dietary component. High tannin concentration may also contribute to its role in preventing diarrhea and intestinal infections, supporting its traditional use in gastrointestinal treatments.

The combined presence of phenolics, flavonoids, and tannins in *the A. digitata* fruit pulp underscores its pharmacological potential, particularly in antioxidant defense, immune modulation, and disease prevention.

Table 2. Quantitative Phytochemical analysis of *A. digitata*

Total phenolic content	Total Flavonoid content	Total Tannin content
127.23±0.99mgGE/g	80.12±1.44mgRE/g	165.47±1.11mgTAE/g

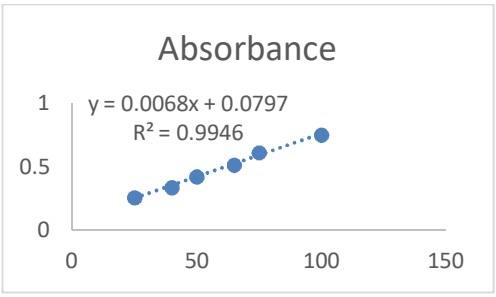

Figure 1. Calibration curve of Gallic acid

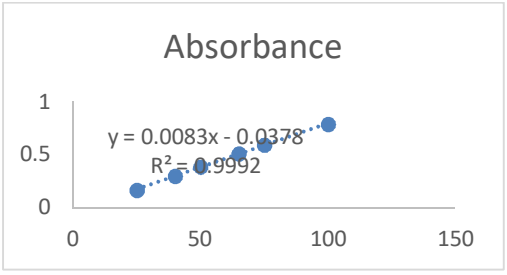

Figure 2. Calibration curve of Rutin

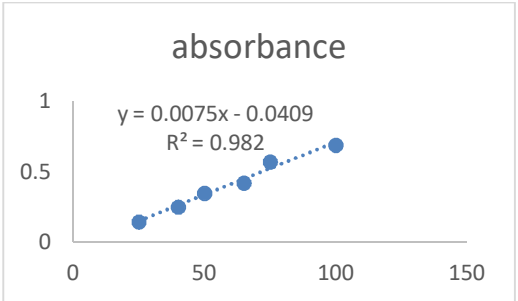

Figure 3. Calibration curve of Tannic acid

3.3. Antioxidant Activity

3.3.1. DPPH Free Radical Scavenging Activity

The DPPH assay results indicate that *Adansonia digitata* (AD) fruit pulp extract exhibits significant free radical scavenging activity, although it is slightly lower than the standard antioxidant ascorbic acid. At the highest concentration (75 µg/mL), AD showed 67.15% inhibition, whereas ascorbic acid exhibited 83.73% inhibition. As the concentration decreased, the scavenging activity also declined, with AD showing 45.77% at 50 µg/mL and 27.46% at 25 µg/mL compared to 64.80% and 36.59% for ascorbic acid, respectively. At the lowest concentrations, AD demonstrated moderate activity, with 15.70% inhibition at 10 µg/mL, which was slightly higher than that of ascorbic acid at 12.14%. The IC_{50} value of AD (53.85 µg/mL) was higher than that of ascorbic acid (40.38 µg/mL), suggesting that a higher concentration of AD extract is required to achieve 50% inhibition compared to ascorbic acid. These findings indicated that AD possesses substantial antioxidant activity, although it is slightly less potent than the standard. The antioxidant potential of AD may be attributed to its polyphenolic and flavonoid content, which act as free radical scavengers.

Table 3. DPPH Free Radical Scavenging Assay

Concentration µg/ml	Ascorbic acid	AD
75	83.7335	67.147
50	64.799	45.7705
25	36.5935	27.4615
15	24.465	19.152
10	12.139	15.6975
0	0	0
IC_{50}	**40.38**	**53.85**

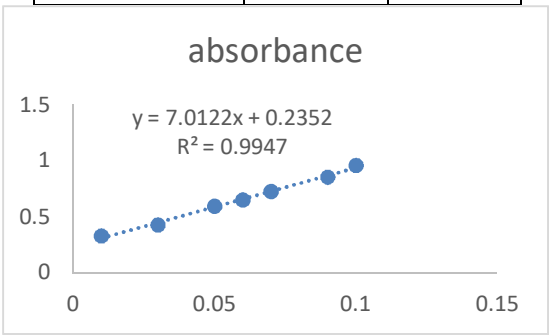

Figure 4. Calibration curve of Ascorbic acid

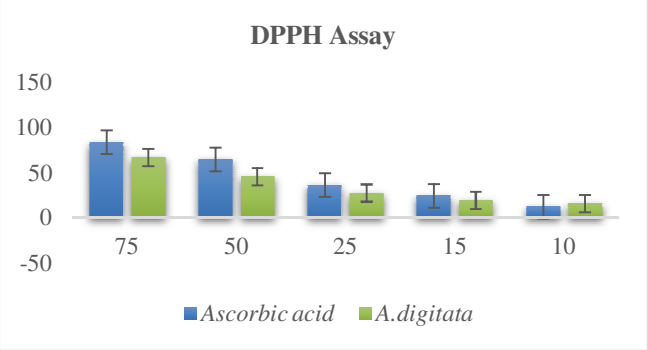

Figure 5. DPPH Free Radical Scavenging Assay

3.3.2. Nitric Oxide (NO) Free Radical Scavenging Activity

The NO scavenging assay revealed that the AD extract exhibited stronger inhibition of nitric oxide radicals than ascorbic acid. At the highest concentration of 75 µg/mL, AD demonstrated an inhibition of 82.53%, surpassing that of ascorbic acid (63.37%). Even at lower concentrations, AD maintained significant activity, with 63.02% inhibition at 50 µg/mL and 46.78% at 25 µg/mL, compared to 65.18% and 39.98% for ascorbic acid, respectively. Notably, at 15 µg/mL, AD exhibited 50.84% inhibition, significantly higher than ascorbic acid (17.91%), while at 10 µg/mL, AD showed 36.33% inhibition compared to 15.69% for ascorbic acid. The IC_{50} value for AD (33.06 µg/mL) was lower than that of ascorbic acid (47.57 µg/mL), indicating that AD is more efficient in scavenging NO radicals than the standard. This suggests that the AD extract has pronounced nitric oxide scavenging potential, possibly due to the presence of bioactive compounds that effectively neutralize reactive nitrogen species. Given its superior NO-scavenging ability, AD fruit pulp may have therapeutic potential in conditions involving oxidative and inflammatory stress.

Table 4. NO Free Radical Scavenging Assay

Concentration µg/ml	Ascorbic acid	AD
75	63.3656	82.5339
50	65.1784	63.0154
25	39.9846	46.7826
15	17.9117	50.8408
10	15.6869	36.3281
IC_{50}	47.57	33.06

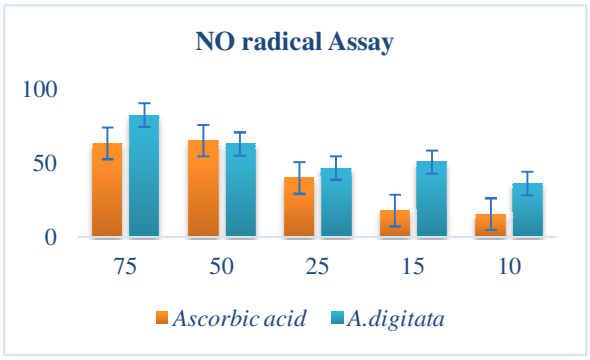

Figure 6. NO Free Radical Scavenging Assay

IV. SUMMARY

The present study investigated the phytochemical composition and antioxidant potential of *Adansonia digitata* fruit pulp, emphasizing its relevance as a functional food with immunomodulatory properties. Qualitative phytochemical screening confirmed the presence of bioactive compounds, including flavonoids, tannins, saponins, and terpenoids, which contributed to the pharmacological efficacy of *A. digitata*. The quantitative analysis revealed a high concentration of phenolics (127.23 ± 0.99 mg GAE/g), flavonoids (80.12 ± 1.44 mg RE/g), and tannins (165.47 ± 1.11 mg TAE/g), which are known to possess potent antioxidant, antimicrobial, and anti-inflammatory properties. These findings support the traditional use of baobab fruit pulp for managing infections, inflammation, and oxidative stress-related disorders.

Antioxidant assays demonstrated the significant free radical scavenging activity of *the A. digitata* extract. The DPPH assay showed moderate antioxidant activity, with an IC_{50} value of 53.85 µg/mL, indicating that a higher concentration of the extract is required to achieve 50% radical inhibition than ascorbic acid. However, the nitric oxide (NO) scavenging assay revealed the superior activity of *A. digitata* (IC_{50} = 33.06 µg/mL) compared to the standard antioxidant, highlighting its strong potential in mitigating reactive nitrogen species. The substantial antioxidant efficacy of baobab pulp is attributed to its high polyphenolic and flavonoid content, which contributes to neutralizing oxidative damage and modulating immune responses.

V. CONCLUSION

A. digitata fruit pulp exhibits significant phytochemical richness and antioxidant potential, reinforcing its role as a natural dietary intervention for immune support and metabolic health. The bioactive compounds present in baobab pulp can enhance immune function by reducing oxidative stress, regulating cytokine responses, and maintaining homeostasis of the gut microbiota. These findings validate the traditional medicinal applications of *A. digitata* and suggest that it could be utilized as a functional food to promote immune resilience and combat oxidative stress-associated diseases. Further in-depth clinical studies are warranted to explore direct immunomodulatory mechanisms and therapeutic potential in human health.

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CONFLICT OF INTEREST

The authors declare no conflicts of interest relevant to this article.

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