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Superior Free Radical Scavenging Potential of Cajanus scarabaeoides (L.) Du-Petit-Thours

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Abstract

The exploration of wild edible plants as sources of natural antioxidants is critical for developing sustainable nutraceutical resources. Cajanus scarabaeoides (L.) Du–Petit–Thours (Fabaceae), a wild relative of pigeon pea widely consumed by tribal populations in Gadchiroli district, Maharashtra, India, was investigated for its antioxidant potential. Methanolic extracts of the edible seeds were subjected to DPPH radical scavenging assay to evaluate free radical neutralization capacity. The extract exhibited pronounced concentration-dependent antioxidant activity, with percentage inhibition ranging from 4.33% to 85.56% at concentrations between 5 and 320 µg/ml. The calculated IC_{50} value was 63.80 µg/ml, indicating strong radical scavenging efficiency relative to the standard ascorbic acid (IC_{50} = 23.27 µg/ml). The superior activity suggests a high concentration of bioactive phytoconstituents, particularly phenolic compounds and flavonoids known for their redox properties and structural capacity to stabilize free radicals. The results highlight C. scarabaeoides as a promising natural antioxidant source with significant potential for incorporation into functional foods, nutraceutical formulations, and preventive dietary strategies aimed at mitigating oxidative stress–induced disorders. The study provides scientific validation of its traditional dietary use and supports further phytochemical and pharmacological investigations.

Keywords: Cajanus scarabaeoides; Fabaceae; Antioxidant activity; DPPH assay; Phenolics; Functional foods; Wild legumes.

1. Introduction

1.1 Oxidative Stress, Legumes, and Functional Nutrition

Oxidative stress plays a central role in metabolic disorders, including atherosclerosis, insulin resistance, and inflammatory conditions (Halliwell & Gutteridge, 2015). Legumes are widely recognized as functional foods due to their rich composition of proteins, dietary fiber, vitamins, and polyphenolic antioxidants (Middleton et al., 2000).

Flavonoids, isoflavones, and phenolic acids present in leguminous plants exert potent antioxidant and anti-inflammatory effects through hydrogen atom transfer, electron donation, and modulation of cellular antioxidant enzymes (Rice-Evans et al., 1995; Vinson et al., 1995).

1.2 Fabaceae Family and Phytochemical Significance

The Fabaceae family is one of the largest plant families and includes nutritionally significant crops such as pigeon pea (Cajanus cajan), soybean, and lentil. Numerous Fabaceae members are documented to contain quercetin, kaempferol, genistein, and catechin derivatives, compounds known for high radical scavenging efficiency (Hertog et al., 1995; El & Karakaya, 2004).

Wild relatives of cultivated legumes often possess enhanced phytochemical diversity due to natural adaptation and genetic variability. However, these wild species remain largely underutilized and scientifically neglected.

1.3 Botanical and Ethnobotanical Profile

Cajanus scarabaeoides is a wild relative of pigeon pea and grows naturally in forested regions of Maharashtra. Locally known as "Junglee Tur," its seeds are consumed by tribal communities during winter seasons. While cultivated pigeon pea (Cajanus cajan) has been extensively studied for antioxidant and anti-inflammatory properties, the wild species C. scarabaeoides has received limited biochemical attention. Given its genetic proximity to cultivated legumes, it is reasonable to hypothesize a rich phenolic composition and significant antioxidant activity.

1.4 Research Gap and Study Objective

There is limited documentation regarding the antioxidant properties of C. scarabaeoides from Indian tribal regions. Evaluating its free radical scavenging activity can provide insights into its nutraceutical value and contribute to biodiversity-based food security strategies.

The present investigation therefore aims to assess the antioxidant potential of methanolic seed extracts of Cajanus scarabaeoides using the DPPH radical scavenging assay and to analyze its comparative efficiency relative to standard antioxidants.

2. Materials and Methods

2.1 Collection and Identification

Mature pods and aerial plant parts of Cajanus scarabaeoides (L.) Du–Petit–Thours were collected during the post-monsoon and early winter season (October–December), coinciding with seed maturation. The plant samples were obtained from naturally growing populations in forested tracts surrounding Kamlapur village, Gadchiroli district, Maharashtra, India. The region's subtropical climatic conditions and fertile forest soils support the growth of wild leguminous species. Specimens were collected from multiple sites within the study area to ensure representative sampling. The collected material was inspected to exclude insect-infested or damaged parts. Seeds were separated from pods manually, cleaned, and air-dried under shade conditions to preserve bioactive compounds.

Botanical identification was conducted by a qualified taxonomist based on morphological characteristics, including leaf arrangement, pod morphology, seed structure, and floral traits, with reference to standard taxonomic manuals. The species was authenticated as Cajanus scarabaeoides (L.) Du–Petit–Thours (Family: Fabaceae). A properly mounted and labeled voucher specimen was deposited in the departmental herbarium of Raje Dharamarao College of Science, Aheri, to serve as a permanent record for future scientific verification.

2.2 Extraction of Plant Material

The cleaned and shade-dried seeds of Cajanus scarabaeoides were finely powdered. About 25 g of seed powder was subjected to Soxhlet extraction with methanol for 6–8 hours. The methanolic extract was filtered and concentrated using a rotary evaporator under reduced pressure. The concentrated extract was stored at 4°C in amber-colored bottles for subsequent antioxidant evaluation.

2.3 DPPH Free Radical Scavenging Assay

The antioxidant potential of the plant extracts was evaluated using the DPPH (2,2-diphenyl-1-picrylhydrazyl) radical scavenging method following the procedure described by Perumal and Saravanabhavan (2018). A freshly prepared 0.135 mM solution of DPPH in methanol was used for the analysis. Different concentrations of the plant extracts (20–320 µg/ml) were prepared, and 1 ml of each concentration was added to 2.5 ml of the DPPH solution.

The reaction mixtures were vortexed thoroughly to ensure homogeneity and then incubated at room temperature for 30 minutes in the dark to prevent photodegradation of the DPPH radical. After incubation, the absorbance was recorded at 517 nm using a UV–Visible spectrophotometer against methanol as the blank. Ascorbic acid served as the standard antioxidant (positive control).

The percentage inhibition was calculated as:

% DPPH inhibition = [(OD of control - OD of test)/ (OD of control)] x 100

(Perumal, P. And Saravanabhavan, K., 2018)

The IC_{50} value (the concentration required to scavenge 50% of DPPH radicals) was obtained from the inhibition curve plotted against extract concentration.

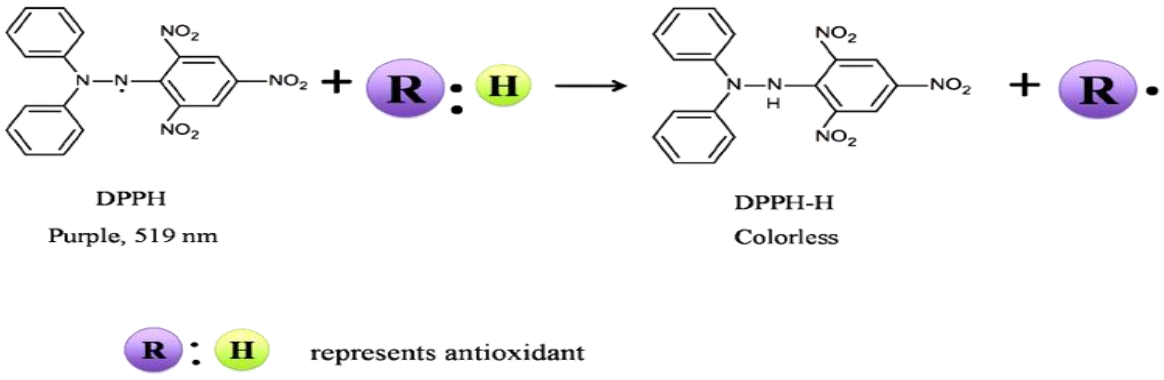
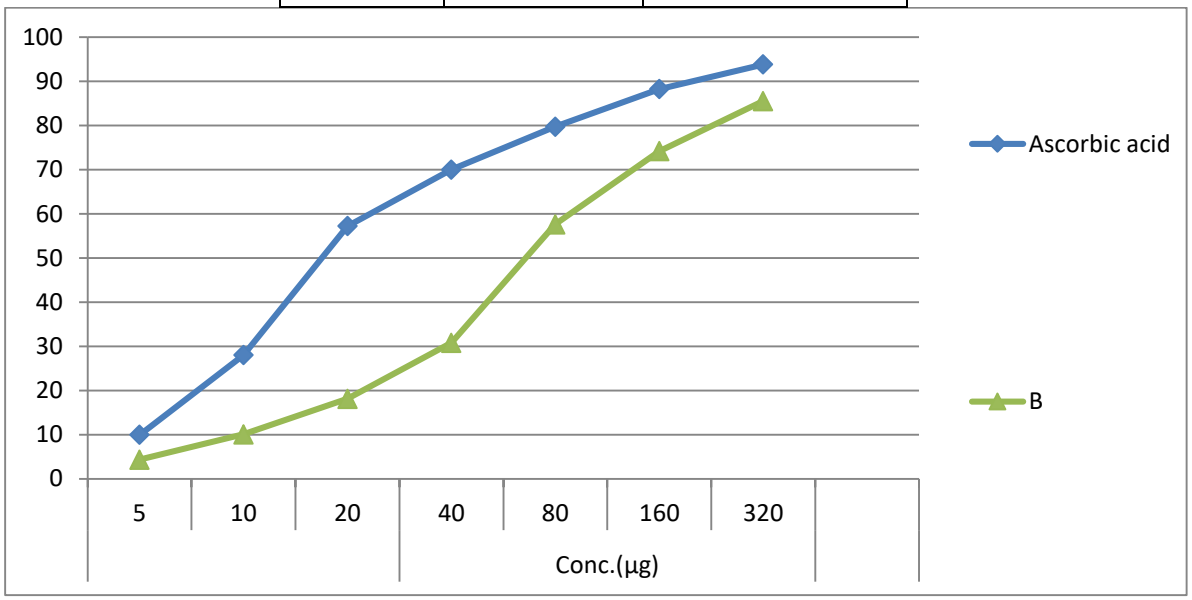


Figure 1: Mechanism of action of antioxidant vs DPPH . R: R is an antioxidant radical; H is an

antioxidant radical scavenger. David D. Kitts, 2014. Courtesy

Table 1: Concentration Vs Mean Values of % inhibition

Conc.(µg)	Ascorbic acid	(B)C. scarabaeoides
5	9.972	4.334
10	28.006	10.065
20	57.223	18.127
40	70.037	30.801
80	79.730	57.642
160	88.257	74.185
320	93.849	85.555



Graph 1: The IC50 values in **µg/ml**: **B(63.80)** and **Ascorbic acid** = **23.27 µg/ml**.

3. Results and Discussion

3.1 DPPH Radical Scavenging Capacity

All tested extracts demonstrated concentration-dependent increases in free radical scavenging activity (Table 1).

Concentration (µg/ml)	Ascorbic Acid	C. scarabaeoides
5	9.97	4.33
10	28.01	10.07
20	57.22	18.13
40	70.04	30.80

80	79.73	57.64
160	88.26	74.19
320	93.85	85.56

The IC_{50} values were calculated as follows: C. scarabaeoides 63.80 µg/ml and ascorbic acid 23.27 µg/ml.

3.2 Mechanistic Insight and Phytochemical Correlation

The DPPH radical scavenging assay demonstrated pronounced concentration-dependent antioxidant activity in the methanolic seed extract of Cajanus scarabaeoides. The mechanism of DPPH reduction involves hydrogen atom or electron donation by antioxidant molecules, leading to stabilization of the purple DPPH radical into its non-radical yellow form.

The relatively low IC_{50} value (63.80 µg/ml) indicates strong radical scavenging efficiency, suggesting the presence of substantial quantities of redox-active phytoconstituents. Given that members of the Fabaceae family are rich in phenolic acids, flavonoids, isoflavones, and tannins, the observed activity is likely attributable to these compounds.

Wild relatives of pigeon pea, including C. scarabaeoides, are genetically diverse and often accumulate higher levels of protective secondary metabolites as adaptive responses to environmental stress. Phenolic compounds such as quercetin, kaempferol, genistein, and catechin derivatives—commonly reported in Fabaceae—are known for their ability to donate hydrogen atoms, chelate metal ions, and interrupt free radical chain reactions.

The strong inhibition percentage observed at higher concentrations (85.56% at 320 µg/ml) further supports the presence of potent antioxidant constituents in the seed extract.

3.3 Comparative Discussion with Literature

Within the Fabaceae family, cultivated legumes such as Cajanus cajan have been extensively documented for their antioxidant and anti-inflammatory properties. The antioxidant performance of C. scarabaeoides demonstrates comparable radical scavenging trends, although slightly lower than the standard ascorbic acid (IC_{50} = 23.27 µg/ml).

The IC_{50} value of 63.80 µg/ml positions C. scarabaeoides among legumes with strong natural antioxidant potential. Variability in antioxidant capacity among Fabaceae species is often influenced by genotype, ecological habitat, soil nutrients, and seasonal conditions. As a wild species growing in forest ecosystems of Gadchiroli district, C. scarabaeoides may accumulate diverse phytochemicals due to environmental adaptation pressures.

Compared to many underutilized wild legumes, the antioxidant efficiency observed in this study is notably significant. Such findings reinforce the hypothesis that wild edible legumes represent valuable yet underexplored nutraceutical resources.

3.4 Potential Applications and Future Prospects

Given its strong antioxidant activity, Cajanus scarabaeoides holds considerable promise as:

1)A natural antioxidant ingredient in functional foods
2)A candidate for nutraceutical formulation
3)A dietary supplement for oxidative stress management
4)A biodiversity-based food security resource

Its traditional consumption by tribal communities gains scientific validation through the present findings. Incorporating its seeds into dietary formulations could enhance antioxidant intake, particularly in rural and forest-dependent populations.

Future research should focus on:

1) Quantitative estimation of total phenolic and flavonoid content
2) Isolation and structural characterization of individual bioactive compounds
3) Comparative solvent extraction studies
4) Evaluation using additional antioxidant models such as ABTS, FRAP, nitric oxide scavenging, and lipid peroxidation assays
5) In vivo pharmacological validation

Such studies would strengthen its candidacy as a functional legume with therapeutic relevance.

4. Conclusion

The methanolic seed extract of Cajanus scarabaeoides exhibits strong, concentration-dependent DPPH radical scavenging activity with an IC_{50} value of 63.80 µg/ml. Although less potent than ascorbic acid, its significant antioxidant capacity highlights the presence of biologically active phenolic constituents.

These findings scientifically substantiate its traditional dietary use and underscore its potential as a sustainable natural antioxidant source. Further phytochemical and pharmacological investigations are warranted to fully explore its nutraceutical and therapeutic applications.

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