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Comparative account on Bioactive potential of *Cajanus cajan* (L.) Millsp. and *Cajanus scarabaeoides* (L.) Thouars.

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Abstract

The nutraceutical, phytochemical, and bioactive properties of *Cajanus cajan* and *Cajanus scarabaeoides* were compared in a study. While *C. scarabaeoides* has the ability to produce bioactive substances, *C. cajan* is commonly grown for its nutritional and medicinal qualities. Both species are resilient to harsh environments. Both herbs have been used traditionally to cure a variety of illnesses. In Nigeria, *C. cajan* is used to treat cancer. Pigeon pea is rich in protein, fats, carbohydrates, and ash, making it a valuable food source in India. During malting, protein to *C. cajan* (21 mg/g) and fat content increase, while ash content decreases. Processing methods like de-hulling can lead to nutrient losses. Pigeon pea has potential to mitigate protein deficiency, with varying nutritional content per 100 grams.

C. scarabaeoides was higher in total free amino acids (7.18 mg/g) than *C. cajan* (5.59 mg/g). *C. scarabaeoides* also has more soluble sugars (8.34 mg/g) than *C. cajan* (6.67 mg/g), but not significantly. However, *C. cajan* contains more soluble phenols (1.29 mg/g) than *C. scarabaeoides* (0.97 mg/g). *C. scarabaeoides* has higher protein content (28.26 mg/g) compared PPI hydrolysates shows antioxidant capacities, indicating potential as bioactive peptides for functional food ingredients. *C. scarabaeoides* and *C. cajan* exhibit significant antioxidant properties, with potential applications in health foods. *C. cajan* also shows higher nitrate reductase activity compared to *C. scarabaeoides*. Additionally, methanolic and methanol extracts of *C. cajan* demonstrate antidiabetic effects, suggesting a role in diabetes management.

Keywords: nutraceutical, phytochemical, *Cajanus scarabaeoides*, *Cajanus cajan*, bioactive compound

Introduction:

Cajanus is a genus in the Fabaceae family with approximately 37 species found throughout the tropical and subtropical areas (Gargi et al., 2022). *C. cajan* (pigeon pea) is the most widely farmed and important species due to its high nutritional value, providing essential proteins and elements, as well as its therapeutic properties.

On the other hand, *C. scarabaeoides* (wild pigeon pea), though less well-known and underutilized, holds significant potential due to its bioactive compounds and notable pharmacological and genetic properties. Both species are valued for their ability to withstand extreme conditions, including drought. (Dey and Sinha 2015; Dinore et al., 2024)

Traditional Uses:

An ethnobotanical analysis of *Cajanus scarabaeoides* revealed that, thanks to a variety of chemical components, including secondary metabolites with therapeutic value, it can be used as a remedy for a variety of ailments. Microscopically examining the leaves and stems revealed unique anatomical traits, which helped distinguish between different plant components. Important pharmacogenetic and physicochemical characteristics were also found for use in subsequent study. Notably, *C. scarabaeoides* alcoholic stem extract demonstrated potent parasite-killing properties, suggesting that it may be useful in the treatment of filarial infections. Furthermore, the plant's nutritional advantages and therapeutic properties contribute to its significance as a significant resource for the

production of food and feed. (Wanjari et al., 2023).

Ahisdi reported the utilization of *C. cajan* for treating cancer in South-western Nigeria in a separate study. Referred to as Arhar or Tuvar, the plant's leaves have flavonoids, tannins, resins, and terpenoids, and a paste from the leaves is commonly used to heal mouth sores and swelling (Upadhyay 2010). The Leaf extract of *C. scarabaeoides* (L.) Thouars is used as traditional treatment of jaundice, diabetic also used as antidote against food poisoning, gingivitis, stomatitis, and constipation (Upadhyay 2010). The root paste of *C. scarabaeoides* applied with coconut oil to check falling hairs to cure baldness (Sharma M and Kumar 2013)

Nutraceuticals

1. **Proximate analysis:** Pigeon pea, a nutritious vegetable, has an impressive nutritional profile. The moisture level of the leaf powder is 9.20%, whereas the stem powder is 8.6%. Ash data show that total ash content is 12.80% for leaves and 6.90% for stems, with water-soluble ash at 2.9% (leaf) and 1.3% (stem), and acid-insoluble ash at 2.2% (leaf) and 1.4% (stem) (Kolhe and Patil 2021).
2. **Nutrient value:** Pigeon pea is a crucial source of high-quality protein (Talari and Shakappa 2018), providing approximately 20-22% protein, 1.2% fat, 65% carbohydrates, and 3.8% ash. This nutritional profile is particularly significant for the vegetarian population in India, where pigeonpea contributes to dietary protein intake (Sarkar et al., 2020)

Pigeon pea, shows significant changes in protein content and fat content during malting. The moisture content decreases with germination time, while protein content increases. Ash content decreases, potentially affecting nutritional value. Crude fiber decreases, potentially reducing disease risk. Fat content is lower in malted samples, indicating a leaner food option. These changes in protein, ash, and fat content contribute to the overall nutritional profile of pigeon pea. (Nwosu and Nwosu 2013)

This Pigeon pea is abundant in starch, protein, calcium, manganese, crude fiber, fat, trace elements, and minerals, underscoring its significance as a dietary staple. However, processing methods such as de-hulling can lead to nutrient losses that adversely affect its nutritional profile (Saxena, Kumar, and Sultana 2010)

The *C. cajan* shows the nutritional and therapeutic advantages of pigeonpea, emphasizing its potential to mitigate protein deficiency in developing economies. With a protein content ranging from 21-26%, pigeonpea serves as an excellent dietary option for individuals who cannot afford meat. (Rama Karri and Nalluri 2017). Per 100 grams, the nutritional profile of *Cajanus cajan* includes carbohydrates ranging from 19.5 to 23.9 grams, serving as an energy source. Protein content varies between 7.2 and 21.0 grams, making it significant for vegetarian diets, while fat is low, ranging from 0.9 to 2.3 grams. Crude fiber, which supports digestive health, is present in amounts from 2.3 to 8.2 grams, and ash content, indicating mineral content, ranges from 1.4 to 1.6 grams. The vitamins include Vitamin C, an antioxidant, ranging from 4.80 to

569.2 mg, and Vitamin A (β -Carotene), supporting vision, from 0.05 to 0.36 mg. Key minerals include potassium (552 to 1392 mg) for heart health, phosphorus (127 to 367 mg) for bone health, and calcium (16.3 to 200.9 mg) for bone strength. Additionally, essential amino acids per 100 grams include leucine (0.2 g), lysine (0.3 g), valine (0.2 g), and isoleucine (0.2 g). (Wu et al., 2024).

C. scarabaeoides shows Crude protein ranges from 28 % to 36 % in green foliage of pigeon pea (Phatak et al. 1993). Although *C. scarabaeoides* is not more explored by Dey conducted comparative study between two species results show below

Total Free Amino Acids: *C. scarabaeoides* exhibits a higher total free amino acid content (7.18 mg/g) compared to *C. cajan* (5.59 mg/g) (t-value: 3.31, $p < 0.05$). (Dey et al., 2017)

Soluble Sugar Content: *C. scarabaeoides* has elevated soluble sugar levels (8.34 mg/g) in comparison to *C. cajan* (6.67 mg/g), though this difference is not statistically significant (t-value: 1.99). (Dey et al., 2017)

Soluble Phenol Content: *C. cajan* (1.29 mg/g) contains significantly more phenol than *C. scarabaeoides* (0.97 mg/g) (t-value: 4.96, $p < 0.05$). (Dey et al., 2017)

Soluble Protein Content: *C. scarabaeoides* presents a higher protein content (28.26 mg/g) than *C. cajan* (21 mg/g), yet the difference is not statistically significant (t-value: 0.06) (Dey et al., 2017). Pigeon pea seeds typically contain about 20-22% protein and notable amounts of essential amino acids and minerals, rendering them a valuable nutritional resource for both humans and animals (Abebe 2022).

Phytochemical Composition:

The phytochemical analysis of *Cajanus scarabaeoides* and *Cajanus cajan* revealed a rich profile containing coumarins, cardiac glycosides, tannins, phenols, and flavonoids. Quantitative assessments showed that the methanol extract had the highest levels of total phenolic, tannin, and flavonoid content.

- A total of 21 unsaponifiable compounds were identified in the hexane extract, including notable compounds such as phytol, beta-sitosterol, stigmasterol, and campesterol. Additionally, 12 fatty acids were detected, with 9,12-octadecadienoic acid and palmitic acid being the most prominent (Hassan et al., 2016).
- Quercetin-3-O-beta-D-glucopyranoside was isolated from *Cajanus cajan* for the first time, along with other flavonoids such as orientin, vitexin, quercetin, luteolin, apigenin, and isorhamnetin (Hassan et al., 2016).
- Specific compounds identified include hexadecanoic acid methyl ester, α -amyrin, β -sitosterol, pinostrobin, longistylin A, and longistylin C (Ashidi et al., 2010)

The phytochemical analysis of *Cajanus scarabaeoides* seed extracts revealed a rich profile containing coumarins, alkaloids, cardiac glycosides, tannins, phenols, and flavonoids. Quantitative assessments showed that the methanol extract had the highest levels of total phenolic, tannin, and flavonoid content (Gargi et al., 2022; Pattanayak et al., 2010; Rokkam et al., 2024).

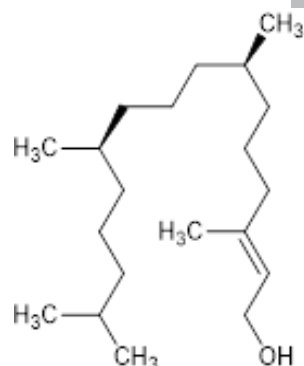
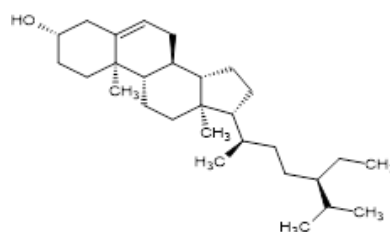
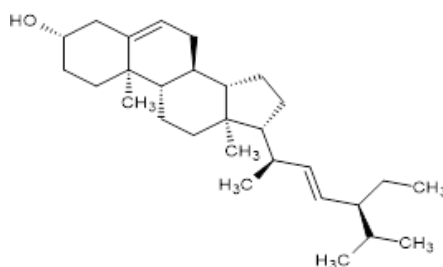
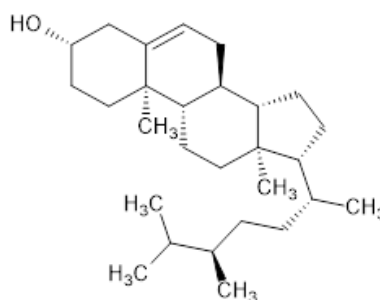
**Phytol****beta-sitosterol****Stigmasterol****campesterol**

Fig 1: Compounds identified in phytochemical analysis.

Bioactive potential

1. Anti-diarrheal activity:

The study on *Cajanus scarabaeoides* revealed its antidiarrhoeal properties through phytochemical analysis. The methanol extract, which yielded 8.94%, showed significant antidiarrhoeal activity in various experimental models. In the castor oil-induced diarrhoea model, the methanol extract significantly reduced feces and diarrheic feces, while loperamide showed a higher inhibition. The methanol extract also delayed intestinal transit, indicating its potential to treat diarrhoea. The results suggest the methanol extract's traditional use in herbal medicine for treating diarrhoea. Further studies are recommended to isolate active constituents. (Pattanayak et al., 2010)

2. Antioxidant Activity:

PPI hydrolysates are shown in the study to have antioxidant properties indicating that it is useful source of bioactive peptides. These peptides may find application as functional dietary additives in the fight against hypertension and oxidative stress. Peptide sequences from PPI digests were analysed for their bioactivities using the BIOPEP database, which revealed ACE inhibition and antioxidant characteristics. Free radical scavenging and metal chelation in food formulations are two of PPI's functional uses (Tapal et al., 2019).

Cajanus scarabaeoides exhibits significant antioxidant inhibition, with 45.54% activity ((Dey and Sinha 2015) Additionally, the butanol fraction of *C. cajan* seeds displayed antioxidant properties through DPPH radical scavenging activity, with an IC₅₀ value of 9.07 mg/ml (Hassan et al. 2016)

Various extracts (aqueous, ethanol, ethyl acetate, n-butanol, petroleum ether) from *C. cajan* leaves were also tested for antioxidant potential using the DPPH radical-scavenging assay and the β -carotene-linoleic acid test. The findings showed that these extracts, along with compounds such as cajaninstilbene acid, pinostrobin, vitexin, and orientin, possess valuable antioxidant properties, indicating potential applications in medicine and health foods (Pal et al., 2011).

3. Nitrate Reductase Activity:

Cajanus cajan (3.4 $\mu\text{moles NO}_2 \text{ h}^{-1}\text{g}^{-1}$) shows significantly higher activity compared to *C. scarabaeoides* (1.59 $\mu\text{moles NO}_2 \text{ h}^{-1}\text{g}^{-1}$) (t-value: 7.45, $p < 0.05$) (Dey et al., 2017).

4. Antidiabetic Effects:

In alloxan-induced diabetic rats, the methanolic extract significantly lowered fasting blood sugar levels; the greatest impact was shown 4-6 hours after injection. This suggests that *C. cajan* may have a role in the treatment of diabetes (Pal et al., 2011). In streptozotocin-induced diabetic mice, the methanol component of red gram markedly lowered blood glucose levels; a significant reduction was seen at the 10-hour post-administration ($p < 0.01$) (Habib et al., 2010). The aqueous extract raised normal rats' fasting blood glucose levels when tested on streptozocin-induced Type 2 diabetic rats. This draws attention to a complicated interplay that might help manage hypoglycemia brought on by too much insulin or hypoglycemic drugs. (Pal et al., 2011).

5. Hypcholesterolemic Effects

A stilbene-containing extract from *C. cajan* was found to reduce the atherogenic properties of dietary cholesterol in mice. This effect was associated with increased expression of hepatic Low-Density Lipoprotein receptors and enhanced bile acid synthesis, suggesting a role in cholesterol management (Pal et al. 2011).

6. Microbial Activity:

The extracts exhibited significant inhibitory effects against microbial strains, including *Staphylococcus aureus* and *Escherichia coli*. In vivo studies further demonstrated the antimicrobial potential of *C. cajan* (Pal et al. 2011).

7. Antifilarial activity

The study explores the antifilarial activity of *Cajanus scarabaeoides* (EECs) extract, which has shown significant effectiveness against the filarial nematode *Setaria cervi*. The extract, enriched with bioactive polyphenols like resveratrol and ferulic acid, was found to be selectively toxic to filarial parasites while nontoxic to mammalian cells and tissues. The extract's mechanism of action involves oxidative stress, leading to a redox imbalance, activating the nematode's CED pathway, ultimately causing the parasite's death. The extract's simple, cost-effective preparation method makes it a viable option for further development. (Ray et al. 2018).

8. Anti-Inflammatory Activity:

Cajanus cajan hexane extract revealed a considerable ability to prevent carrageenan-induced inflammation. The treatment reduced inflammation by 85% and 95% at dosages of 200 mg/kg and 400 mg/kg, respectively, three hours

after the carrageenan challenge. The extract also significantly reduced serum levels of inflammatory indicators, such as tumor necrosis factor-alpha (TNF- α) and interleukin-6 (IL-6), by 11% and 20%, respectively. (Pal et al., 2011)

9. Immunomodulatory Effects:

The hexane extracts significantly reduced immunoglobulin G (IgG) serum levels in rats with carrageenan-induced inflammation, indicating possible immunomodulatory actions. (Pal et al., 2011)

10. Antinociceptive Activity:

The study evaluated the antinociceptive effects of the hexane extract using the writhing test in mice. The results showed that the extract reduced the number of writhings by 61% and 83% at doses of 200 mg/kg and 400 mg/kg, respectively (Hassan et al., 2016)

11. Cytotoxicity Activity:

The methanol extract of *Cajanus cajan* exhibited the highest cytotoxicity among all tested extracts, with an IC₅₀ value between 5-10 μ g/mL (Ashidi et al., 2010)

Hypocholesterolemic Effects:

The stilbenes-containing extract-fraction from *Cajanus cajan* (SECC) reduces atherogenic properties of dietary cholesterol by enhancing hepatic LDL-receptor and cholesterol-7-alpha-hydroxylase expression, improving bile acid synthesis, and lowering LDL cholesterol in mice. A methanol extract of *C. cajan* seeds significantly reduced lipid levels in streptozotocin-induced mice. An isolated compound (CCA1) from *C. cajan* also showed strong hypolipidemic activity. Additionally, a *C. cajan* diet improved cholesterol levels

in hypercholesterolemic hamsters by boosting CPT-1, LDL-receptor, and antioxidant enzyme activities. In diabetic rats, *C. cajan* beverages reduced cholesterol levels by 19.78%. (Gupta Rakesh Kumar 2021).

Toxicity:

The exposure to *C. cajan* leaf extracts led to significant weight changes in female rat kidneys and male rats, with no significant differences observed after a 2-week recovery period. Behavioral observations showed reduced motility, abdominal distention, and poor grooming in rats treated with high-dose ethanol extract. Body weight gains were consistent and positive during both exposure and recovery periods, with no significant differences compared to controls. Acute toxicity tests showed no deaths and consistent weight gains. (Tang et al., 2017)

Conclusion:

To put it briefly, the pigeon pea (*Cajanus cajan*) and its wild relative, *Cajanus scarabaeoides*, have the potential to be significant sources of nutrients and have medicinal qualities. It is a possible source of lean protein because studies have revealed that important nutrient values have been altered by processing procedures like malting, including an increase in protein and a decrease in fat content. Its rich Phytochemicals variety, which includes a multitude of secondary metabolites, also makes it safe to use medicinally in the treatment of a wide range of illness, from filarial infections to diarrhea. Because of its antibacterial, antidiabetic, anti-inflammatory, and antioxidant qualities, pigeon pea has emerged as a functional meal that can help developing

countries fight chronic illnesses and hunger. Growing interest in pigeon pea's bioactive peptides, natural antioxidants, and pharmaceutical uses necessitates more study into isolating bioactive chemicals and streamlining extraction techniques. These results are critical to improving food security, advancing sustainable agriculture, and bringing this underutilised crop into the mainstream globally.

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