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Assessment of Nutritional, Chemical and Biological Potential of Cajanus cajan (L.) Millsp.

Dolly Barhaiya[1] and Dr. Vinod Dubey[2]
Research Scholar, Awadhesh Pratap Singh University, Rewa, (M.P.), India[1]
Department of Chemistry, Sanjay Gandhi Government P. G. College, Sidhi, (M.P.), India[2]

Abstract: *In this paper deals with the genus Cajanus (Family: Fabaceae) consists of approximately 37 species, and Cajanus cajan (C. cajan) is a significant member of the genus. It is a commercial legume crop widely grown in sub-tropical and semi-arid tropical areas of the world. C. cajan is well known for its folk medicinal uses to treat various disorders, such as toothache, dizziness, diabetes, stomachache, female ailments and chronic infections. These properties have been linked to the presence of several value-added nutritional and bioactive components. Different solvent extracts from C. cajan (leaves, root, stem and seeds) have been evaluated for their phytochemical and biological activities, namely antioxidant, antimicrobial, antidiabetic, neuroprotective, and anti-inflammatory effects. Taken together, and considering the prominent nutraceutical and therapeutic properties of C. cajan, this review article focuses on the important details including ethnomedicinal uses, chemical composition, biological applications and some other medicinal aspects related to C. cajan nutraceutical and pharmacological applications.*

Keywords: legumes; *Cajanus cajan*; bioactive compounds; nutraceuticals; bioactive effects.

I. INTRODUCTION

India contributes significantly to global grain legume production, accounting for approximately 90% of global production and ranking sixth in terms of production and area cultivated Mahitha, B. at al (2015). Most legume species belong to the Fabaceae or Leguminosae families and are depicted due to their fruits generally known as pods. Recognized for their great significance as dietary supplement for humans and animals, these legumes, such as pea, cowpea, chickpea, soybean, mung bean, beans, fava beans, lentils, peanut and pigeon pea, have been increasingly investigated for nutraceutical purposes De Ron, A.M. (2015).

Grain legumes are often considered as nature's treasure offered to mankind and are regarded as "poor man's meat" because of their high quantity of vitamins, minerals, protein (16-50%) and dietary fiber (10-23%) Maphosa, Y at al ((2017). Moreover, grain legumes also play a crucial role in ecological services, due to their biological nitrogen fixation capacity Dutt, A. at al (2022).

Cajanus cajan (L.) Millsp. is a leguminous annual woody or perennial plant Akande, K at al (2010), and the genus Cajanus consists of approximately 37 species out of which C. cajan is an extensively used commercial legume crop Ganapathy, K. at al (2011). It is a native genus from ancient Egypt, Africa, Asia and America, and now it has been widely distributed across the tropical and subtropical regions Orni, P.R. at al (2018). Globally, *C. cajan* has been recognized by various names, like Pigeon pea red gram, tur, arhar, dal (India); Asia is the main producer of pigeon pea, and India alone contributes approximately to 77% of the total area and 90% of the total production around the world (Jeevarathinam, G. and Pande, S. at al (2011 and 2016). Despite the high potential of pigeon pea as a crop, the plant as a whole has been shown to be beneficial for use as food, feed and fuel thanks to its high nutritional value. Thus, the need to implement prior information about *C. cajan* and compile it for convenient access constitutes the main motivation for this work. In this sense, the present study includes all relevant information from the digital platform on the ethnomedicinal uses, bioactive constituents, nutritional value and biological applications lant tion oxication Roots Roots (O) Seeds (T) Seeds (O) Leaves and Seeds (T) Leaves (O) India China Bangladesh India India Saxena, K.B. and Mula, M. (2010)

gunga pea, congo pea and non-eye pea in some other parts of the world Jeevarathinam, G. et al (2020). Asia is the main producer of pigeon pea, and India alone contributes approximately to 77% of the total area and 90% of the total production around the world Pande S, Abdulkareem, K.A., (2021). Despite the high potential of pigeon pea as a crop, the plant as a whole has been shown to be beneficial for use as food, feed and fuel thanks to its high nutritional value. Thus, the need to implement prior information about C. cajan and compile it for convenient access constitutes the main motivation for this work. In this sense, the present study includes all relevant information from the digital platform on the ethnomedicinal uses, bioactive constituents, nutritional value and biological applications of C. cajan, also paying attention to aspects related to its geographical distribution and folk consumption.

II. BOTANICAL DESCRIPTION

C. cajan is a perennial drought resistance legume commonly cultivated in the subtropical and semi-arid tropical areas of the world Nix, A., et al.(2015). India is the prime producer, corresponding to approximately 90% of the total global production. It has also been found since ancient times in Africa, Caribbean, Southeast Asia, and Egypt and has been grown at a wide range of altitudes (up to 3000 m) Sameer Kumar, C. et al. (2017). C. cajan is from the Genus Cajanus, Family Fabaceae, Order Rosidae, Class Magnoliopsida, and Kingdom Plantae Orni, P.r. et al (2018).

2.1 Cytology

The cytological analysis of C. cajan showed that it is diploid having 2n = 2x = 22 chromosomes with an average length of 5.73 ± 1.15 um up to 10.92±2.69 μm and dominantly metacentric in shape, consisting of 14 metacentric and 4 submetacentric chromosomes Yuniastuti, E. et al. (2021). C. cajan has a genome of size 858 mega-base pairs Ariraman, M. et al (2016). In the comparative genetic characterization of wild and cultivated C. cajan genotypes, the cultivated species present maximum polymorphic lociGanapathy et al (2011).

2.2 Morphology

From a morphological point of view, C. cajan a short-lived shrub with erect stems of 1-2 m height Fuller, D.Q. et al (2019). Its roots are finely nodulated, lateral and deep rooted of to up 3 m, possessing a root system having a central taproot with several secondary and lateral branches. The branching pattern in C. cajan is determined based on the habitat, spacing and plant genotype. The leaves are lanceolate to elliptical in shape and size, ranging from 6 to 17 cm in length and are around the same breadth. The flowers are usually, yellow to orange in color, present a long peduncle of 1-8 cm long and terminal or axillary racemes (4-12 cm). Calyx: gamosepalous with 5 lobes, Corolla: zygomorphic and bright yellow, Androecium: 10 stamens (4 with short filaments and 6 with long filaments), Gynoecium: ovary (superior, pubescent, 2-9 ovules and monocarpellary), style (long, filiform and glabrous), stigma (incurved & thickened), Seeds: spherical or lens shaped Sameer Kumar, C. et al (2017).

III. TRADITIONAL USES

The use of C. cajan for traditional purposes dates since immemorial times, and such information has passed over the generations in order to substantially promote the continuity of knowledge improvement. The diversity and availability in regional flora of plant resources is markedly determined by the use of plant species in folk medicinal practices Karpaviciene, B. (2022). Various studies have demonstrated that the leaves, seeds, stems and roots of C. cajan have been used in traditional medicine for the treatment of various ailments, including toothache, diabetes, dizziness, baldness and gastrointestinal discomfort in few domains of India, Bangladesh, China and many other nations. In Oman, C. cajan seeds are used for treating many chronic infections, and native people use the juice from leaves to treat various dermatological conditions Tungmunnithum, D. et al. (2020). In ancient times, the floral decoction was used for treating pneumonia, coughs, menstrual disorders, dysentery and bronchitis, while leaf

IV. NUTRITIONAL PROPERTIES

The nutritional profiling of *C. cajan*, including of its leaves, seeds, roots and stem, has also been investigated by standard methods to determine the proximate, amino acid and mineral composition. The maximum fat (15.000.090%), moisture (8.200.229%), carbohydrate (40.95 ± 0.244%) and nutritive value (333.73 ± 1.500%) were recorded in seeds, however the highest protein content was found in leaves (31.99 ± 0.070%) (Table 2). Results of the proximate composition of protein isolate, full fat flour and defatted flour derived from C. cajan and its comparisons with wheat flour and yellow-pea flour.

The study of amino acids content present in C. cajan reveals that leaves (808.8 ± 10.3 mg/100 g) and roots (871.8 11.2 mg/100 g) contain the highest concentration of glutamine, whereas alanine (1547.8 ± 3.9 mg/100 g) and aspartic acid (11.56 g/16 gN) were found in maximum amounts in seeds. The lowest concentration of tryptophan was observed in leaves (2.4 ± 0.4 mg/100 g), roots (1.3 ± 0.4 mg/100 g) and seeds (9.5 ±0.1 mg/100 g). The detail description of the amino acid composition is mentioned.

To what concerns to mineral composition, the evaluation of C. cajan revealed higher levels of calcium in leaves (33 ± 4.9 mg/100 g), seeds (581 ± 4.3 mg/100 g) and roots (597 ± 2.5 mg/100 g) and lower levels of zinc (2.1 ± 0.9, 0.7 ± 0.2 and 0.7 ± 0.9 mg/100 g, respectively) (Table 5). Due to the nutritional contribution and health benefits of C. cajan it is regarded as an alternative to produce vegetable meat, with high quality standards and appropriate sensory characteristics that allow consumer acceptance and integration of product in daily diet. Moreover, due to its essential nutrient content, this makes an exquisite preference for vegetarian consumers. Scientific investigations of nutraceutical profiling have underlined that C. cajan has relevant nutritional attributes that help in the treatment of different types of human conditions.

V. CHEMICAL COMPOSITION

The composition and concentration of active compounds presents in plant matrices largely determines their bioactive effects. In C. cajan the main bioactive compounds identified to date are broadly classified into the flavonoids, phenolics and stilbenes group. The literature-based screening of phytochemicals revealed the presence of various phenolic compounds, namely, cajanol, longistylin A and C, genistein and biochanin A . The total phenolic content of C. cajan seeds, root and stem was estimated to be between 4.27-92.00 mg of gallic acid equivalent (GAE) per gram dry weight (DW) (mg GAE/g DW) extract by using different solvent systems (dichloromethane, water and methanol) . The determination of the chemical composition of ethanol leaves extract by high-performance liquid chromatography (HPLC) analysis revealed the presence of seven flavonoids, including pinostrobin, orientin, naringenin, apigenin, apigenin-6,8-di-C-x-L-arabinopyranoside and pinostrobin chalcone, and two stilbenes, namely cajaninstilbene acid and longistyline C. In a study, Zhang and colleage reported the structure of a novel prenylated flavonone isolated from C. cajan, naringenin-3'-isoprenyl-7-methyl ether 1, by 1D and 2D NMR technology. Other phytochemical studies also indicated the existence of acidic compounds, glycosides, tannins, resins, saponins and reducing sugars. The description of the bioactive components present in different parts of C. cajan is shown in Figure 1 and Table 6.

Looking at the essential oil from C. cajan, Ogunbinu et al. identified the presence of 100 constituents in seeds, stem and leaves using gas chromatography (GC) and gas chromatography-mass spectrometry (GC-MS) analysis. Among all compounds, sesquiterpene hydrocarbons were found in higher amounts in 81.2% (stem), 92.5% (leaves), and 94.3% (seeds). Esters, aldehydes, alcohols, terpenoids and ketones and some other constituents, including a-himachalene, ß-himachalene, y-himachalane, a-humulene and x-copaene were also identified. Qi et al. reported the presence of 27 compounds in the essential oil from C. cajan leaves extracted through solvent-free microwave extraction (SFME) and hydro-distillation (HD) methods. Sesquiterpenes were the most abundant compounds identified, namely a-humulene, x-copaene, a-bisabolene, a-himachalene, ß-caryophyllene and alloaromadendrene. The details of other constituents.

VI. BIOLOGICAL APPLICATIONS

With the growth of world's economy and enhancement in people's living standard, several chronic diseases, like neurological, metabolic, inflammatory, cerebrovascular and cardiovascular disorders have increased rapidly. Natural products are widely recognized for their biological or pharmacological potential since ancient times, and recently the interest in their study has re-emerged as upcoming drug candidates. Globally, around 50,000 plants have shown potent therapeutic potentialities . According to pharmacological studies, C. cajan leaves have various bioactivities, including antioxidant, antiplasmodial, anticancer, hypoglycemic, insecticidal, neuroprotective and antimicrobial activities. Moreover, the molecular regulatory mechanism of few biological applications/activity are briefly summarized. The most relevant therapeutic applications of C. cajan briefly described below and presented.

6.1 Antimicrobial Activity

The antimicrobial activity of plants varies pronouncedly depending on chemical constituents presents, hence it is difficult to classify single antimicrobial mechanisms, as they rely on the phytochemical properties of the plant. Dinore and Farooqui (2022) investigated the antimicrobial activity of C. cajan leaves methanol extract against Escherichia coli and Candida albicans, and the results indicated a remarkable ability to inhibit the growth of the microorganisms, with minimum inhibitory concentrations (MIC) of 50 µg/mL and minimum fungicidal concentrations (MFC) of 250 µg/mL. Cajanuslactone, one of the most abundant phytoconstituents present in C. cajan leaves is expected to be the…

6.2 Antioxidant Activity

Different studies also have been performed to assess the antioxidant potential of different parts of C. cajan. Aggarwal et al. (2015) reported the antioxidant potential of *C. cajan* ethanol seed extract using ferric reducing antioxidant power (FRAP) assay. The results obtained revealed a concentration-dependent antioxidant activity (concentration 25 to 450 µg, 4.4 to 43.0 µM).

6.3 Anti-Diabetic Activity

The antidiabetic potential of *C. cajan* methanol root extract was addressed by Nahar et al. (2014) in alloxan-induced diabetic Swiss albino mice. The experimental mice were treated with C. cajan extract up to 5 days (200 and 400 mg/kg bw, orally). Glucose tolerance test and hyperglycemic effect studies (involving diabetes induction in mixed sex Swiss albino mice by injection of aqueous alloxan monohydrate, 55 mg/kg, intravenously) were carried out on tested animals, along with determination of the antioxidant activity. The results showed a rapid decline in fasting serum glucose level ($p < 0.001$) and blood glucose level ($p < 0.001$) in 5 days. On the basis of these results, the plant extract evidenced potent hypoglycemic and antioxidant properties compared to other species (e.g., Tamarindus indica seeds).

6.4 Tyrosinase Inhibitory Activity

C. cajan root, stems and seeds were also addressed for its ability to inhibit tyrosinase activity, and for that water, dichloromethane and methanol extracts were prepared. The IC50 values of the extracts varied from 3.55-12.43 mg/mL, whereas the maximum inhibitory capacity was reported for methanol root extract (IC50 = 3.55 mg/mL.

6.5 Neuroprotective Activity

A variety of naturally-occurring bioactive compounds are currently being explored for their therapeutic potential in neurodegenerative diseases, but only a few are known to have benefits. The use of plant extracts and their bioactive constituents are one of the promising approaches for the treatment of neurological diseases. *C. cajan* was also exploited for their neuroprotective abilities. The presence of stilbenoids is able to induce apoptotic neuronal death by Aß25-35 injection in mice and cause elevation in choline acetyltransferase (ChAT) and superoxide dismutase (SOD) activity in the cortex and hippocampus. In a study with injured larvae of zebrafish, cajanin stilbene acid (CSA) and its derivative were found to decline the migration and production of primitive macrophages and neutrophiles, being thus proposed that *C. cajan* may be a promissory source of biomolecules with neuroprotective abilities.

6.6 Other Bioactivities

In addition to the above listed bioactive effects of *C. cajan*, other bioactivities, such as hepatoprotective, anthelminthic, anticancer and anti-inflammatory effects have been documented by other researches. Moreover, the *C. cajan* is also used in paper-making, cosmetic industries and multi-purposely in dietary supplements for human and animals.

VII. CONCLUSIONS AND FUTURE PROSPECTS

Pigeon pea (*C. cajan*) is one of the most commonly and widely used, tropical and subtropical legume due to its nutrient packed edible seeds, might being effectively used for food and medicinal purposes. However, it is an underutilized/neglected legume species. As yet, several flavonoids, isoflavonoids, tannins, phenolics and proteins have been isolated from various plant parts, and their therapeutic properties have also been confirmed, but many pure and bioactive components were still not taken into consideration. Several studies have identified that the phytochemicals present display excellent bioactive effects plethora of human conditions

A number of extensive research has been done only on extracts rather than isolated fractions and oils, that indicates necessity of further study in this direction. Moreover, majority of studies are limited to in vitro screening, with only a few focusing on in vivo testing. As a result, advanced research is required to explore new phytopharmaceuticals based on *C. cajan*. Clinical trials should be conducted to assess the toxicity profile of C. cajan in humans in respect of antioxidant activity, antimicrobial activity, anthelminthic activity, anti-inflammatory activity, ant diabetic activity and immunomodulatory aspects. The current review article aims to concentrate attention of researchers as well as pharmaceutical industries on untouched and unexplored aspects related to *C. cajan* and may serve as a crucial link towards the establishment of *C. cajan* as a therapeutic drug. Although, as it is a leguminous plant and plays a major role in biological nitrogen fixation, further more relevant knowledge regarding the characteristics of soil, indigenous microbes and plant species-specific responses is required to establish the inoculants for maximum ecological restoration benefits and to support future adoption of this practice.

Table 1: Ethnomedicinal uses of Cajanus cajan from different regions

Sr. No.	Medicinal Use	Plant Part	Region
1.	gastrointestinal discorders	Seeds (O)	Trinidad an Tobago
2.	Menstrual problems	Seeds (O)	India
3.	Toothacke	Stem(T)	India, China
4.	Sedative	Seeds(O)	India
5.	Wounds	Stem(T)	India
6.	Diabetes	Seeds, Leaves(O)	Bangladesh, India
7.	Laxaive	Leaves (O)	India and China
8.	Dizziness	Seeds (T)	India
9.	Poultice	Seeds (T)	India
10.	Poultice	Seeds (O)	India
11.	Wormicide	Seeds, Roots	India
12.	Baldness	Seeds (T)	India
13.	Gingivitis, Stomatitis, Toothbrush	Stem, Seeds, Leaves (T)	India, China, thailand
14.	Genital inflammations	Leaves (T)	India
15.	Malaria	Leaves (O)	India
16.	Ulcers	Leaves (T)	India
17.	Syphilis	Roots (O)	India
18.	Cough	Roots (O)	India
19.	Measles	Seeds (T)	China
20.	Energy stinulant	Seeds (O)	Bangladesh
21.	Induce Lactation	Leaves Seeds (O)	Bengladesh
20.	Mullify effect of intoxication	Leaves (T)	India

Table 2 Promimate composition of Cajanus cajan from different countires

Proximate	Seeds (%) Nigeria	Seeds (%) India	Seeds (%) Taiwan	Seeds (%) India	Leaves (%) India	Leaves (%) Nigeria	Leaves (%) India	Roots (%) Taiwan	Roots (%) Taiwan	Stem (%) India
Dry matter	95.89	91.80±0.22	-	-	-	93.68±0.284	-	-	93.88±0.12	-
Protein	21.03	08.62±0.03	22.0±0.4	25.46	22.40	31.99±0.070	19.4±0.5	2.4±0.1	21.34±0.56	19.53±0.02
Fat	4.43	15.00±0.09	5.5±0.3	1.65	2.74	13.00±0.090	-	0.4±0.0	14.19±0.26	1.64±0.03
Fibre	7.16	05.09±0.08	-	6.50	7.25	21.82±0.238	-	-	27.70±0.36	4.75±0.02
Ash	3.76	22.11±0.11	12.0±0.0	3.66	8.22	20.60±0.114	3.6±0.1	3.6±0.2	23.00±0.22	3.23±0.03
Moisture	-	8.20±0.22	14.3±0.1	8.50	11.20	06.31±0.284	11.5±0.2	3.3±0.1	06.11±0.12	8.17±0.02
Carbohydrate	-	40.95±0.24	56.2±0.3	54.23	-	6.269±0.153	65. ±0.2	90.6±0.1	8.131±0.38	62.28±0.05
Nutritive value	-	333.73±1.50	-	-	-	236.72±0.591	-	-	242.61±1.56	-

Table 3 Comparison of Cajanus cajan flour proximate composition with generally used flours.

Proximate	Full Fat flour (Cajanus cajan)	Defatted Flour (Cajanus cajan)	Protein Isolate (Cajanus cajan)	Wheat Flour (Triticum aestivum)	Yellow-Pea Flour (Pisumsativum)
Protein	24.02±0.016%	26.30±0.016%	90.65±0.025%	12.81±0.06%	22.33±0.05%
Moisture	6.85±0.012%	6.76±0.016%	6.63±0.015%	12.70±0.0%	14.84±0.93%
Fibre	1.24±0.016%	1.56±0.015%	-	10.08±1.20%	14.84±0.93%
Fat	2.017±0.062%	-	-	1.53±0.08%	1.40±0.04%

Table 4 Amino acid composition of dufferent parts of Cajans cajan

Amino Acids	Seeds (mg/100g)	Leave (mg/100g)	Roots (mg/100g)
Lysine	740±63	425.4±10.1	297.9±2.0
Histidine	361.7±3.6	266.8±1.3	118.4±4.3
Arginine	279.9±2.6	333.4±1.3	226.1±5.9
Aspertic acid	126.4±1.7	323.3±5.2	112.5±5.2
Threonine	136. ±5.4	406.8±1.3	119.9±4.6
Serine	220.0±8.1	494.6±4.8	169.2±
Glutamic acid			
Proline	72.1±8.2	137.9±1.2	89.1±8.1
Glycine	160.7±3.4	235.7±2.8	139.7±6.9
Alanine	1547.8±3.9	576.5±5.6	687.5±12.3
Cystine	-	-	-
Valine	671.4±4.8	422.2±3.6	381.1±5.6
Methionine	70.6±1.6	86.0±2.3	61.1±1.2
Isoleucine	392.0±3.1	314.1±8.3	272.7±4.2
Leucine	679.7±13.5	597.8±3.8	492.2±4.2
Tyrosine	186.1±2.0	143.9±3.9	149.8±5.2
Phenylalanine	354. ±7.6	612.4±3.6	262.1±2.5
Tryptophan	9.5±0.1	2.4±0.4	1.3±0.4
Glutamine	648.3 ±6.3	808.8±10.3	871.8±11.2

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