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Review Article

The Pharmacological and Therapeutic Activities of *Canavalia gladiata* (Jacq.) DC.

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Abstract

Canavalia gladiata is a perennial ethnomedicinal climber food plant found throughout the World. It shows many therapeutic properties which can be utilized for the treatment against many human diseases. In this review, we surveyed the recent findings on the pharmacological and therapeutic properties of *Canavalia gladiata*. The objective of this is to provide detail analysis on active compounds present in this species and to provide information regarding its pharmacological activities on human diseases and safety. Its bioactive compounds possess outstanding pharmacological properties like hemagglutinating activity, HIV-I inhibition, antimicrobial, antiproliferative, hepatoprotective, ROS- inhibitor, anti-cancer and anti-diabetic properties has been studied. The chemical constituents, pharmacological activities and therapeutic studies of *C. gladiata* showed a promising medicinal plant with various chemical compounds and numerous pharmacological activities.

Keywords: Pharmacological activities, Therapeutics, Bioactive compounds, *Canavalia gladiata*.

Introduction

Plant has been used as source of food and medicine from time immemorial¹. *Canavalia gladiata* (Jacq.) DC. is a climber species of family Fabaceae and subfamily Papilionoideae². In English commonly known as Sword Bean, in Hindi it is called Badi-Sem and Mahasimbi in Sanskrit³ and other names are listed in table no. 1. *Canavalia gladiata* is an ethnomedicinal food plant which has abundant health promoting bioactives, particularly fruits and seeds. The fruit and seeds are reservoir of health promoting macromolecules such as proteins (bioactive peptides), polysaccharides (α - amylase), phytochemical (flavonoids) and vitamins. Health promoting properties make these bioactive molecules suitable candidate for the development of novel food and nutraceutical products. This review demonstrate the bioactive compounds of fruit and seeds with diverse potential of fruit and seed extract (FE/SE) for treating hepatic diseases, anti-diabetic, antiproliferative, anticancer and antimicrobial agent. Utilization of bioactive molecule can improve economic feasibility of the fruit and seeds processing industry and may help to improve the quality of life ^{4, 5}. Fruits and seeds are loaded with phytochemical compounds such as canavanine, concanavalin A, flavonoids,

gallotannins, lectins, phenols, tetragalloyl hexoside, triterpens, 4-OMGA and α - amylase⁴.

The fruit and seeds are rich source of nutrition compounds including proteins, amino acids, fatty acids, fiber and functional compounds with notable nutraceutical properties^{3, 5, 6}. The morphology of sword bean is shown in figure 1. The fruits are harvested from plant, they are washed and sorted. Extraneous materials are removed from the fruits are then sorted manually. The fruits/seeds were homogenized into fine powder separately and extractions of Sword Bean Extract (SBE) were made on solvent basis (figure 2).

Numerous bioactive constituent have been identified from fruits includes protein (26.15 %), carbohydrates (49.9 %), fats (7.84 %) and fiber (8.34 %)⁴. Due to their high protein content, fruit/seeds have been used as vegetable protein supplements. Owing to their stability and antioxidant properties, it is used in rural and ethnic food system. The generation of antioxidants, enzymes and bioactive compounds are some of the practical applications of fruit/seeds along with production of bioenergy⁵.

This review highlights the beneficial aspect of fruits and seeds in terms of human health which is attributed to their superior

phytochemical profile a comprehensive discussion of fruit/seeds and there extracts in various biomedical activities is well discussed along with illustrative representation. The detail discussions are given below.

Taxonomy of *Canavalia gladiata* (Jacq.) DC. is given in table no. 2.



Figure 1: (a) Habit of *Canavalia gladiata* (b) Fruit (c) Seeds

Table 1: Vernacular Names of *Canavalia gladiata* (Jacq.)DC⁵.

India	Badi Sem, Mahasambi, Sagapputampatti, Abai
French	Dolic en sabre
German	Schwertbohne
Spanish	Poroto sable
Japanese	Nata-mame
Arabic	Fûl Hindî
Chinese	Dao Dou
Portuguese	Feijão-De-Porco
Dutch	Zwaardboon
Thai	Thua-Phra

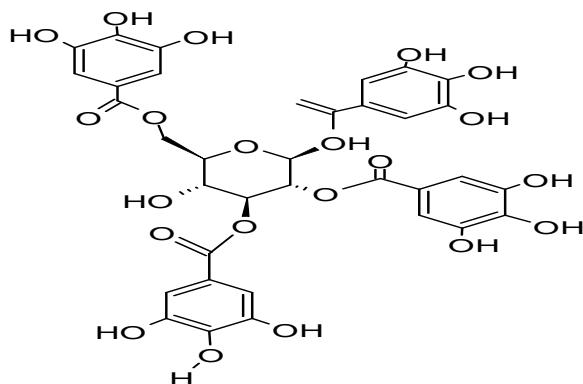
Table 2: Taxonomic classification of *Canavalia gladiata* (Jacq.)DC⁵.

Taxonomic Rank	Taxon
Kingdom	Plantae
Division	Tracheophyta
Class	Magnoliopsida
Order	Fabales
Family	Fabaceae
Genus	<i>Canavalia</i>
Species	<i>gladiata</i>
Common Name	Sword bean/ Badi sem

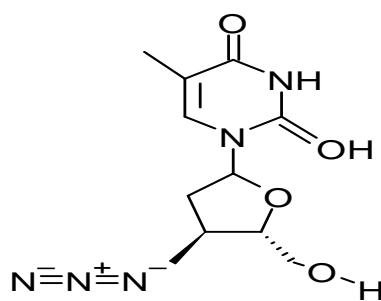
Pharmacological activities

Pharmacological activities include phytochemicals, chemistry and the activities of bioactive compounds present in the biofunctional part/tissues of the plant. These are given separately as

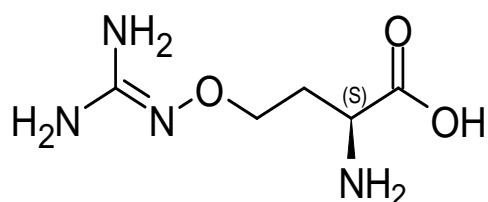
Phytochemistry of *Canavalia gladiata*



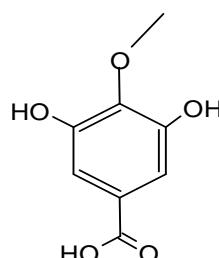
a. Tetragalloyl hexoside



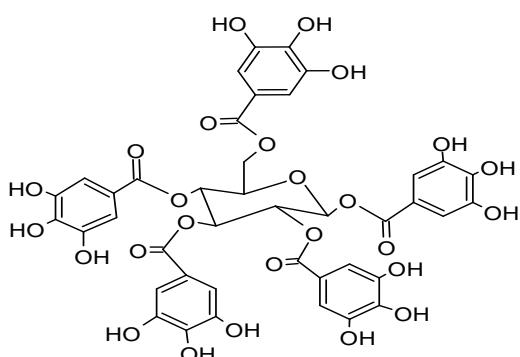
b. Concanavalin A



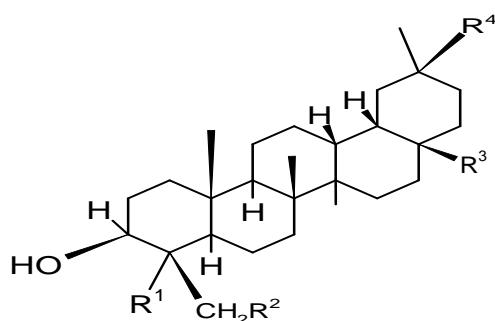
c. Canavanine



d. 4-O-methylgalllic acid



e. General Structure of Gallotannins



f. General Structure of Triterpenoids

Figure 2: Structures of major compounds present in sword bean and their chemical structure

Therapeutic Properties of *Canavalia gladiata* (Jacq.)DC

Canavalia gladiata shows many important therapeutic properties. Some of the reported studies on therapeutic properties are as below:

Antioxidant

Recent finding showed the mature as well as immature sword beans pods to possess antioxidative action which remove free radicals produced in the body and protect against oxidative

stress⁹. Phenol, tannins and flavonoids contribute for the high antioxidant activity in *C. gladiata*¹⁰. The main phenolic compounds present in sword bean are gallic acid and gallotannin, they also observed the presence of bioactive compound tetragalloyl hexoside that showed antioxidant activity¹¹. Flavonoids are polyphenolic compounds present in plant contain benzo- β -pyrone structure¹⁰. The antioxidant activity of raw sword bean (uncooked) have been reported to be very high i.e. $15159.64 \pm 909.33 \mu\text{g}$ Trolox equivalent per gram bean¹². The unique feature among legume is polyphenols i.e. they found that red sword bean had the

highest content of antioxidant polyphenols among 42 edible beans of China and red bean coat was rich in gallic acid and its derivatives mainly gallotannins. Gallotannins rich extract posses may useful bioactive compound and antioxidants¹³.

The first reduction product of molecular oxygen is superoxide radicals, it is observed that superoxide radicals kill the cells, inactivates enzymes and degrade DNA, cell membranes and polysaccharides¹⁴. Superoxide anion is a weak oxidant, when it react in living system it generate hydroxyl radicals as well as

singlet oxygen, both of these contribute to oxidative stress and lead to genesis of several chronic diseases in human beings. The superoxide radical scavenging activity of sword bean is 12-58%¹⁰. Sword bean also shows hydroxyl radical scavenging activity, although hydroxyl radical are short-lived yet most damaging radicals within the body formed from superoxide radicals, hydrogen peroxide and oxide of biological macromolecules viz., lipids, protein and nucleic acid¹⁵ (figure 3).

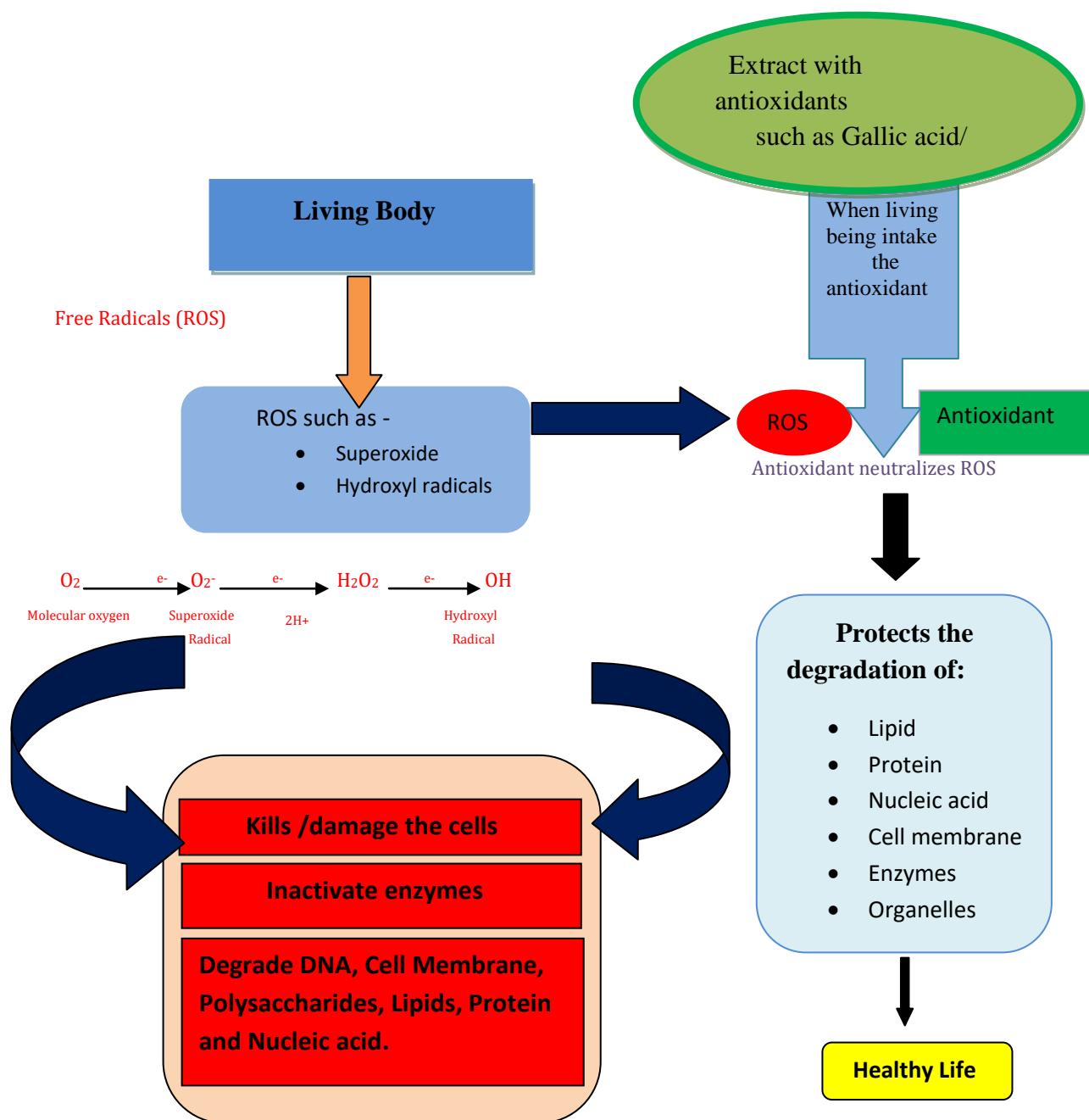


Figure 3: Effect of oxidative stress and countering this effect with antioxidants extracted from *C. gladiata*.

Antiproliferative activity

The antiproliferative activity has been observed in sword bean^{16,17,18} with the analyses of gallotannins, Concanavalin A and lectins. Concanavalin A (Con A) was observed as a potent antihepatoma substance and responsible for cell death, apoptosis and autophagy in cancer cells¹⁹. A lectin was

isolated from sword bean by using maltamyl-sepharose column which had amino acid composition and sugar binding specificity similar to Con A²⁰, lectins are carbohydrate binding protein which are non- immune origin interacts with sugar containing substance, and are capable of specific recognition

and reversible binding to carbohydrate, without altering covalent structure of any glycosyl ligands^{21,22}.

The studies showed that Con A has antiproliferative effect on human A375 melanoma cells²³, mouse B16 melanoma cells²⁴ and human colorectal cancer cells²⁵. Lectins are active potent antineoplastic substance which triggers the apoptosis in the targeted cells¹⁹. Sword bean lectin exhibited a more potent antiproliferative activity on leukemia (L1210) tumor cells than Con A²⁶. Tumor cell surface differ from other normal cells due to glycoconjugate composition, lectins have different specificity towards different cells and the lectins which could identify the malignant tumors could be used as probes for diagnosis of cancer cells²⁷. Lectin from red sword bean show stronger mitogenic activity than Con A at a concentration lower than 120 μ g/ml¹², lectins induce changes in the structure of the carbohydrate moiety of the glycoconjugate during neoplastic transformation in situ as well as in vitro. The effect of lectin of red sword bean and Con A on the proliferative activity of B16 melanoma cells at different concentration viz. low concentration of 15.6, 31.3 and 62.5 μ g per well and high concentration of 125.0 μ g per well. The lectin of red sword bean had antiproliferative activity higher than Con A at concentration of 125.0 μ g per well ($P<0.001$)¹². Con A is known to interfere with cell homeostasis which increases the proliferation of surviving cells²⁸. Canavanine is potential anti-cancer agent along with radiation treatment in can be clinically utilized in treatment of pancreatic cancer²⁹. There are possibilities for use of canavanine for chemotherapeutic agent for treatment of human pancreatic carcinoma³⁰. Lectin having anti-cancer properties are reported to be utilized as a biochemical tools as it has specificity for cancer cells so can be used for identification of cancer cells^{31,32}. A new antiangiogenic agent was developed which has no or minimum toxicity so there is safe treatment of angiogenesis related diseases including cancer. For, this a compound 4-O-methylgallic acid (4-OMGA) was isolated from methanolic extract of seeds of sword bean. The effect of 4-OMGA was investigated on normal as well as tumor cell lines viz., Bovine aortic endothelial cells (BAECs), CHANG cells and HT1080, Ht29, HepG2, MCF-7 cells respectively using colorimetric MTT assay. To ascertain cellular viability of these cells it was treated with different concentration of 4-OMGA for 72 hours. It was reported that 4-OMGA inhibited the proliferation of cell line with different growth inhibitory spectrum within 24 hrs period. 4-OMGA inhibited the growth of endothelial cell viz., BAECs in dose dependent manner (IC₅₀ concentration 15 μ g/mL) whereas non-endothelial cells viz., immortalized normal hepatocyte, fibrosarcoma, colon carcinoma, hepatocarcinoma, and breast carcinoma cells showed more resistant to 4-OMGA (IC₅₀ concentration > 40 μ g/mL). Tumors secrete many factors which have been recognized as tumor angiogenesis activators, bFGF (basic fibroblast growth factor) is one of the angiogenic factor which induces endothelial cell proliferation, migration, and capillary tube formation. So, the effect of 4-OMGA on bFGF stimulated angiogenic phenotypes of endothelial cells viz., cell invasion and tube formation using in vitro assays was investigated, examination of invasiveness of BAECs by Transwell Chamber system with 8.0 μ m pore size polycarbonate filter insert 10 μ g/mL bFGF effectively invaded BAECs by 86% whereas, 4-OMGA inhibited the stimulation of bFGF and in turn invaded BAECs by 6% and 37% at 0.5 μ g/mL and 1.0 μ g/mL respectively. Further, effect of 4-OMGA on Vascular endothelial growth factor (VEGF) production in HT1080 cell was studied, VEGF is a protein responsible for tumor angiogenic responses observed in human tumors. It was reported that when cell were cultured for 16 hours in hypoxic condition i.e. 5% oxygen concentration there was marked increase in VEGF protein secretion by HT1080 cells this is because in hypoxic condition, hypoxia inducible factor-

1a (HIF-1a) get activated which up-regulates transcription of VEGF. Moreover, 10 g/mL of 4-OMGA treatment derive in almost complete inhibition of hypoxic VEGF protein secretion³³.

Antimicrobial activity

Antibacterial activity

The gallotannins exhibited antibacterial activity³⁴. Con A also exhibited antibacterial, antifungal and antiviral activities. Concanavalin directly interfere with growth and multiplication of microorganisms³⁵. It also shows anti-adhesion property which prevent adherence of bacteria to host cells. The seeds of red and white sword bean were extracted with ethanol, methanol and water, each extract was tested to determine its antimicrobial activity against each of the eight test microorganism as, *B. subtilis*, *B. cereus*, *M. luteus*, *L. monocytogenes*, *S. aureus*, *S. typhimurium*, *E. coli*, *P. aeruginosa*. Various concentration of water to methanol was used in ratios as 0:100, 25:75, 50:50 and 75:25. The extract treated with 25:75 (v/v) showed the highest prohibitive activity against all test microorganisms³⁶. Canavanine {2-amino-4 (guanidinoxy) butyric acid} is a non-protein amino acid structure analog to an amino acid Arginine, canavanine being analog of Arginine exhibit and shows antagonist effect and exhibit anti-metabolic effect on organism like bacteria, virus, fungi and even plant and animals as these integrate in the cell nucleus and other protein and inhibit the RNA and DNA synthesis of the organisms, thus mimicking the regulatory and catalytic reaction of arginine metabolism, arginine uptake and other cellular processes. It is believed that main function of arginine is sequestration of nitrogen for embryo growth³⁷. The presence of canavanine is toxic to animals and pest³⁸. The antibacterial potential of leaves and seeds of sword bean extract against human pathogen viz., *E. coli*, *S. aureus*, *P. aeruginosa* and *B. subtilis* were tested by using disc diffusion method. It was found that ethanolic leaf extract of sword bean has highest zones of inhibition as 20.0 mm which was followed by seed chloroform extracts which showed 14.0 mm zone of inhibition against *B. subtilis*. The antibacterial properties of *C. gladiata* on food born pathogenic bacteria to test the antibacterial activity of gallotannin rich fraction such as monogalloyl hexoside isomer, digalloyl hexoside isomer, digallic acid, trigalloyl hexoside isomer, pentagalloyl hexoside isomer⁹. They included two Gram positive and two Gram negative bacteria viz., *S. aureus*, *B. cereus* and *S. flexneri*, *S. enteric* respectively in a single colony of bacteria that was inoculated into MH broth and was incubated for 12 hrs at 37°C. The bacterial suspension of 100 μ L diluted to 1 X 10⁶ colony forming unit (CFU)/mL was evenly spread over MH agar plate 5 mg/mL rich in gallotannin. It was transferred into oxford cups, 5 mg/mL of gallic acid was used as positive control and 200 μ L was used as negative control and all the agar plates were incubated at 37°C for 24 hrs. The evaluation and determination of diameter of inhibition zone (DIZ) was made in which trigalloyl hexoside rich fraction exhibited the highest antibacterial activity for all the selected sample bacteria. Digalloyl hexoside rich fraction exhibited high antibacterial activity against *B. cereus* whereas monogalloyl hexoside rich fraction did not inhibit growth of any of the sample bacteria³⁹.

Antiviral activity

The lectine of sword bean inhibits HIV-I reverse transcriptase which has potency same as an anti HIV-I natural products^{40,41}. The lectin isolated from the sword bean have capability to inhibit the HIV-I reverse transcriptase which was carried out by using ELISA kit, in this DNA is synthesized using HIV RNA viz., reverse transcriptase but rather than radio-labeled nucleotide digoxigenin- and biotin- labeled nucleotide in

optimal ratio was homogenized into DNA synthesized by reverse transcriptase method. The detection of synthesized DNA followed ELISA protocol which followed certain steps as: first the DNA labeled with Biotin binds with the surface of microtiter modular plate which was pre-coated with streptavidin (biotin- binding protein). Secondly dioxigenin antibody, conjugate with peroxidase (anti-DIG-POD) which further binds to dioxigenin-labeled DNA. Thirdly a substrate for peroxidase was added, peroxidase enzyme catalyzes the cleavage of the substrate, which after reaction produce a colored product. ELISA microtiter plate reader was used for reading absorbance of sample at 405 nm which was directly proportional to the level of reverse transcriptase activity. 4-6 ng of recombinant HIV-I reverse transcriptase is used. It was evaluated that lectin inhibited reverse transcriptase with an IC₅₀ is 35 μM⁴².

Anti-diabetic activity

The hepatoprotective activity of gallotannins while antidiabetic activity of gallotannin⁴³. The phenolic compound present in methyl extract of sword bean showed hepatoprotective activity on albino rats⁴⁴. Animal study of streptozotocin-diabetic rats divulge the importance of Canavanine in attenuation of diabetic retinopathy mainly by induction of molecular chaperon proteins, where it was marked that when it was treated with Canavanine alone had no effect on blood glucose (4.0±0.4 mM whereas 3.8±0.3 mM in control animals), when pretreated Canavanine reduced the blood glucose level of STZ-treated animals by 20% (18.8±2.3 mM where 23.6±1.7 mM, p<0.005)⁴⁵. The presence of inhibitor α-amylase in the legume species the presence of inhibitor interferes with the starch therapeutic value of inhibitor by decreasing carbohydrate absorption in diabetic patients and in obese^{46,47}. The experiment on high fat diet streptozotocin rat model to explore the effect of triterpenoids and flavonoid extracted from seeds of *C. ensiformis* and *C. gladiata* by means of ethanol. The rats were divided into 7 groups Group I -Normal Control (3 ml/kg Citrate bufer), Group II- Diabetic control (HFD+STZ 40 mg/kg, i.p), Group III-HFD+STZ+Glibenclamide (5 mg/kg, p.o), Group IV-HFD+STZ+Ethanolic seed extract of CETT (400 mg/kg/p.o), Group V- HFD +STZ+Ethanolic seed extract of CETF (400 mg/kg/p.o), Group VI -HFD+STZ+Ethanolic seed extract of CGTT (400 mg/kg/p.o), Group VII- HFD+STZ+Ethanolic seed extract of CGTF (400 mg/kg/p.o), and weakly rat was weight and blood samples were analyzed for glucose levels. Glucose was administered to all rats (2g/kg/p.o) after 30 min of dosing. Blood samples were collected by tail vein method after every 4 hrs time interval every 1hrs, after this glucose supplementation and glucose level were measured, it was observed from the data obtained from oral glucose tolerance test, all four fractions of CETT, CETF, CGTT, CGTF at dose 400 mg/kg and Glibenclamide 5 mg/kg remarkably reduced the elevated blood glucose level after 4 h oral glucose administration when compared to group of diabetic induced and diabetic control rats. When serum glycosylated Hb level was examined showed increase from 7.8% (control group) to 12.2% (HFD +STZ groups), additionally treatment with these fractions of *C. ensiformis* and *C. gladiata* species showed reduced range of HbA1C levels when compared to diabetic induced groups⁴⁸.

Anti-Inflammatory and Immunological activites

Immunity is the host's defense system present in animals that protects against disease or other foreign bodies. In the host, both innate and adaptive immune system has evolved to respond to eradicate pathogens⁴⁹. The in vitro and in vivo studies of sword bean have been reported to be anti-allergic and anti-inflammatory effect⁵⁰. Canavanine is an iso-form of Concanavalin A (Con A), has known effects on T cell

proliferation and immune enhancement⁵¹. Immunomodulatory effects by activating NK cells⁵². Mixture of *Canavalia gladiata* and *Arctium lappa* extract exhibit immunity enhancing effects by certain ways viz., increasing immune cells, inhibiting inflammatory cytokines, secreting immune activating cytokines, stimulating NK cell activity, suppressing stress related hormones and strengthening brain memory^{52,53,54}. The *C. gladiata* and studied its anti-inflammatory effect on macrophages cell and DSS-Induced Colitis Mouse Model and his study revealed that the sword bean have the property to attenuate the production of NO, IL-6 and TNF-α in the LPS-stimulated RAW264.7 cells in the dose dependent manner from this they concluded that sword bean has anti-inflammatory property and hence is potential herbal medicine for inflammatory diseases⁵⁵. The immature sword bean pod (ISBP) for its anti-inflammatory effect on NO and PGE2 in lipopolysaccharide-induced RAW264.7 cells production of NO decreased in dose dependent manner when treated with different concentration of ISBP extract viz., 24 μM, 19 μM, 14 μM, 10 μM, further high inhibition of NO production was seen at concentration 2 and 5 mg/mL , the amount of PGE2 produced was also decreased when treated with ISBP extract. NO and PGE2 was reduced by ISBP extract its mRNA and protein expression on iNOS and COX-2 was explored, iNOS and COX-2 synthesize certain inflammatory mediators the protein expression of iNOS and COX-2 increased in LPS stimulated cells whereas, the decrease in expression of iNOS and COX-2 was reported when it was treated with ISBP extract, at 5 mg/mL ISBP concentration iNOS was reduced by 61% and COX-2 was reduced by 60%. NF-κB, a major transcriptional regulator of the inflammatory response so, play a major role in inflammatory process development⁵⁶, it exist in inactive form in cytoplasm by forming a complex with inhibitor protein IκBα. When there is any inflammatory stimulation, IκBα is phosphorylated and NF-κB is released. NF-κB, migrates to the nucleus from cytoplasm upregulates the inflammation related genes such as iNOS, COX-2, and pro- and anti-inflammatory cytokines. The ISBP reduced the production of inflammatory mediators viz., NF-κB, iNOS, COX-2 hence, could be used as anti-inflammatory drug⁹. Another such chronic and relapsing inflammatory skin disease is Atopic dermatitis, also known as eczema, it may be hereditary or due to certain environmental factors⁵⁷ currently there is no treatment for atopic dermatitis and development of drugs for its treatment is complex because the principal cause and mechanism of atopic dermatitis pathogenesis still remains unknown, this is because various body system play role in atopic dermatitis pathogenesis^{58,59}. The immunological responses which is probably the part of immune-pathogenesis and that can lead to chronic atopic dermatitis are as follows. On examination of epidermis skin layer of atopic dermatitis patients, marked hike in production of pro-inflammatory cytokines and chemokines viz., CC17/thymus and activation regulated chemokine (TARC) and CCL11(eotaxin)^{60,61}. At initial phase T helper cell type 2 (Th2) activates the IL-4 and IL-10 which induces the atopic dermatitis. The cytokines IL-4 induces the B- cell class switching from IgM to IgE. IgE bind to receptor FcεRI which sensitizes mast cells, this mast cell releases the biologically active mediator histamine (which helps in development of atopic dermatitis pathogenesis). Th2 type cytokines can trigger the invasion of macrophages or eosinophils to the skin, in response to this antigenic stimulation IL-12 is produced and this in turn activate T helper cell type (Th1)^{62,63,64}. The extract of *C. gladiata* fermented with *Aspergillus oryzae* for its immunomodulatory effects on the development of atopic dermatitis like skin lesions in NC/Nga mice. NC/Nga mice developed atopic dermatitis pathogenesis and was characterized by itching, erythema, hemorrhage, hyperkeratosis, and xerosis, all this symptoms were similar to patients with atopic dermatitis. For,

this the fermented *C. gladiata* was extracted with water, and ethanol (30% and 80%) given as dietary supplements to the NC/Nga mice and the effect of supplements was observed on organ weights, morphological and histological observation, scratching behavior, epidermal hydration of dorsal skin, serum immunoglobulin production, infiltration of mast cells, serum histamine production. The dietary supplement of fermented *C. gladiata* attenuated macroscopic and histopathological changes and attenuated the reduced hydration in the dorsal skin of NC/Nga mice when compared with the atopic dermatitis control group. The fermented *C. gladiata* ethanolic extract 30% and fermented *C. gladiata* ethanolic extract 80% groups, in particular, showed a significant decrease in scratching episodes when compared with the atopic dermatitis control group ($p < 0.05$). Fermented *C. gladiata* ethanolic extract 30% and fermented *C. gladiata* ethanolic extract 80% attenuated T helper cells (Th1 and Th2) type cytokine imbalances, mast cell infiltration, and production of serum IgE and histamine. So, Fermented *C. gladiata* showed positive result against atopic dermatitis⁶⁵.

Hemagglutinating activity

Albumin and globulins viz. proteins extracted from seeds of sword bean shows hemagglutinating activity without any specificity against the human 'ABO' system, and as reported by them globulins exhibit stronger agglutinating activity compared to albumin⁶⁶. Sword bean was investigated for hemagglutinating activity by in which lectin was reported to exhibit hemagglutinating activity, further investigation of inhibition of lectine – induced hemagglutination by various carbohydrate, viz., glucose, mannose and rhamnose, sugar samples were diluted by serial two fold dilution method by mixing phosphate buffer saline, all the dilution were mixed in 25 μ l of a solution of lectine with 16 hemagglutination unit. After allowing the mixture to stand for 30 min undisturbed at room temperature 50 μ l of 2% rabbit red blood cell suspension was added to it, bovin serum albumin (BSA) used as negative control and Con A used as positive control. The lectin exhibited specificity toward glucose (at concentration 7.8 mM, 15.6 mM, 31.2 mM, 62.5 mM, 125 mM, 250 mM, 500 mM), mannose (at concentration 15.6 mM, 31.2 mM, 62.5 mM, 125 mM, 250 mM, 500 mM) and rhamnose (31.2 mM, 62.5 mM, 125 mM, 250 mM, 500 mM) at pH 3-11⁴³.

Shortening of gestation period

The effect of *Canavalia* on impregnated mice to see the abortive nature of *Canavalia* and found that there was no adverse or abortive effect due to introduction of *Canavalia* seed flour in certain proportion in diet of mice only, effect is seen when mice were feed with flour of sword bean in certain proportion during first trimester showed the shortening of the gestation period and from examination it was revealed that there were no toxicological effect of sword bean on major organ such as liver, spleen, kidney, intestine, etc⁶⁶.

Conclusion

Sword bean is an underutilized plant which has high amount of protein content and numerous of phytochemicals viz. Phenol, Tannin, Phytic acid, Tannic acid, flavanoids to be active constituent. Researchers are continuously exploring natural products with least or no side effect as alternatives of conventional medicine. The pharmacological studies revealed that the crude extract or active constituents from *C. gladiata* have antioxidant, anti-proliferative, antibacterial, antiviral, anti-diabetic, anti-inflammatory and hemagglutinating activities. However, from the literature survey showed that most of the work done is on mature seeds and very little is known about pharmacological and therapeutics activities of other plant parts viz., immature seeds, pods, leaves, stem, etc.

The literature survey showed the antioxidant activity shown by polyphenols but fail to explain which polyphenols are involved in it. Similarly there is report of phenolic compounds present in sword bean to have hepatoprotective activity but active molecule is not yet known, so that there are lack of precision in bioactive compounds. Limitation were observed as lack of effective dose in many pharmacological activity.

In summary, although *C. gladiata* showed various therapeutic applications further research work should be planed to investigate the main bioactive compounds imparting pharmacological activities and besides these the toxicological studies should also be carried out to know the effective dose concentration. So, it can be recommended that the isolated bioactive compounds of *C. gladiata* to be explored for further practical application.

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Conflict of Interest

We wish to confirm that in our knowledge there is no conflicts of interest associated with this publication

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