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REVIEW ARTICLE

Nutritive and Therapeutic Potential of Pulses in Diabetes Mellitus

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ABSTRACT

Over the last few decades, lifestyle changes have resulted in a drastic increase in incidence of diabetes all over the world, especially in the developing countries. The number of people suffering from diabetes all over the world is increasing progressively. Many treatment modalities have been developed by various systems of medicine all over the world for the management of this disease; however the quality of life of the patients has been compromised in all such treatment approaches.

Nutritional factors in this regard need to be watched for an effective management of the disease and for regaining the health perspective of diabetic patients. One such nutritional component in our diet is pulses. Pulses are a relatively cheaper source of protein than milk, cheese, cashew, almond, meat, fish, etc and hence are valuable for developing countries. But proper methodology to use these in diabetic patients is a lesser known fact. Pulses in *Ayurvedic* texts have also been discussed under *Shimbidhanya varga* (legumes), where their *Kashaya* (astringent) and *Ruksha* (dry) properties have been mentioned and are thereby suggested as *Pathya* (appropriate indicated diet) in *Meha rogas*(diabetes and disorders alike). The present paper aims to discuss the nutritional and therapeutic potential of various pulses in patients of Diabetes Mellitus, both from *Ayurvedic* and modern point of view.

Key words: Antinutrition, Hyperglycemia Legumes, *Pathya*

INTRODUCTION

Diabetes mellitus (DM) is a clinical syndrome characterized by an increase in plasma blood glucose (hyperglycemia). Diabetes has many types but most common are type 1 or type 2 diabetes. Type 1 diabetes is caused by autoimmune destruction of insulin-producing cells (β cells) in the pancreas, resulting in absolute insulin deficiency, whereas type 2 diabetes is characterized by resistance to the action of insulin and an inability to produce sufficient insulin to overcome this 'insulin resistance'. Hyperglycemia results in both acute and long-term problems. Acutely, high glucose and lack of insulin can result in marked symptoms, metabolic decompensation and hospitalization. Chronic hyperglycemia is responsible for diabetes-specific 'micro vascular' complications affecting the eyes (retinopathy), kidneys (nephropathy) and feet (neuropathy).

The prevalence of diabetes mellitus is increasing globally with a rise from about 30 million cases in 1985 to 177 million cases in 2000 and worldwide estimates project that more than 360 million individuals will have diabetes by the year 2030. [1] The main aim of modern medical science for the management of diabetes includes oral hypoglycemic agents, insulin administration along with diet and exercise. Thus modern medical science generally having much focus on the glycemic index of the patient does ignore the overall health and quality of life of the patients. Case-control study was done among type 2 diabetes mellitus patients attending Medicine Outpatient department of a 780-bedded rural medical college located in central India. The overall Health related quality of life of the total study population (cases and controls) was poor. [2]

Ayurveda not only gives offers effective medicines to treat metabolic disorders but also gives the full guidelines for the lifestyle, diet and medications for the prevention as well as the management of such disorders thus adding to the quality of life of the patients.

One of the prime tools of *Ayurveda* is the concept of *Pathya* (indicated therapeutic diet) which has a great role to play in metabolic disorders such as diabetes. Best food articles from each food groups are listed to be consumed in specific manner. Among different types of pulses, *Mudga* (green gram), *Tuvar* (pigeon pea), *Kullatha* (horse gram) etc are recommended to be taken as *Pathya*. Pulses have remained a major source of protein and energy in vegetarian diet. People with type 1 or type 2 DM who are in poor metabolic control, have increased protein requirements. However, the usual amount of protein consumed by people with diabetes is inefficient to compensate for the increased protein catabolism. A

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meta-analysis of randomized controlled longer term experimental trials found that when eaten on their own, pulses including cooked dry beans significantly lowered fasting blood glucose and insulin levels. In studies where treatments were bean-containing high-fiber or low-glycemic diets, glycosylated hemoglobin (HbA1c) was significantly lowered. In fact, the reduction in HbA1c seen in people with Type 2 diabetes (~ 0.48%) was comparable to that achieved by oral medications. [3] Although proteins have great nutritional value but the fact that they possess potent therapeutic potential is a lesser known fact.

MATERIALS AND METHODS

Ayurvedic classics as well as modern medical science texts, compendia, journals and internet publications have been thoroughly reviewed for compiling the relevant data reported about pulses in *Ayurveda*.

REVIEW

Concept and importance of *Pathya* (appropriate indicated diet) and *Apathya* (inappropriate diet)

Treatment of any disease in *Ayurveda* has its first and very basic principle of *nidaan parivarjana* (avoidance of the cause). [4] Diabetes being the consequence of obesity and faulty diet pattern nowadays is especially having a vital role of the proper diet in its treatment policy. As also cited by *Acharya* (ancient learned scholar) *Lolimbraaj* in his text named *Pathyapthya Vibhodhaka*, [5] the one who follows *Pathya* (appropriate diet) doesn't need any medication because *Pathya* is sufficient to maintain the health; and the one who doesn't follow the *Pathyas* also doesn't need any medication because no medication is going to give results in this case. This reference clearly illustrates the importance of diet and lifestyle to be followed by the patient undergoing any sort of treatment. *Pathya* as described in *Ayurveda* is a much proven factor responsible for the prevention and control of diabetes. *Aahaara* as described in *Ayurveda* has *Tarpana* and *Poshana bhavas* (nutritional effects) for the body. Diabetes being a metabolic disorder has a great percentage of its management in the *Pathya*. One such component in our diet is pulse.

Food values of pulses

Pulses or legumes belong to the family *Fabaceae*, with 18,000 species classified into around 650 genera. [6] Pulses are relatively a cheaper source of protein than milk, cheese, cashew, almond, meat and fish etc., hence valuable for developing countries. Pulses, the poor man's meat, are important sources of food proteins consumed all over the world. Consumption of pulses is highest in India as compared to other pulses growing countries due to low purchasing power and religious restrictions on non-vegetarian diet. They are generally good sources of complex carbohydrates (namely dietary fibers) and are rich in proteins (18–25%), soybean being the exception, containing about 35–43% proteins. They are also good sources of vitamin C, riboflavin, and niacin, especially the germinated legumes. Pulse consumption has also been shown to improve the blood lipid profile, reducing total cholesterol, LDL cholesterol, triglycerides, and increasing HDL-cholesterol, and has been associated with decreased body weight. [7]

Pulses have been described as a major content of *Aahaara* (diet) in *Mudagadi varga* in *Sushruta Samhita*, [8] and in *Shamidhanya varga* in *Charaka Samhita*. [9]

Pulses in diabetes

Antinutrition factor of pulses

Legumes are normally consumed after processing, which not only improves their palatability but also increases the bioavailability of nutrients, by inactivating phytic acid, trypsin inhibitors, and hemagglutinins, although resulting in some loss of water-soluble nutrients. [10] Pulses contain several anti-nutritional factors, such as trypsin and chymotrypsin inhibitors, lectins, polyphenols, flatulence factors, lathyrogens, saponins, antihistamines and allergens. The protease inhibitors, lectins and other antinutrients cause toxicity. Heat treatment has been well established to destroy proteinaceous antinutrients, such as protease inhibitors and lectins, but heat treatment destroys some of the amino acids and vitamins as well. For maintaining the nutritional value of food, it is necessary that heating temperature and length of processing do not exceed the optimum temperature required to eliminate the effect of inhibitors. Proteins in pulses are known to interact with lipids, tannins, phytates, flavor compounds and pigments. These interactions occur when pulses are processed and converted into products. It decreases the bioavailability of proteins. Similarly, tannins and phytates interact with minerals and vitamins resulting in a decrease in their bioavailability. Thus, bioavailability of nutrients depends not only on their content in the seed, but also on the interaction of nutrients under various processing conditions. The pulses are subjected to various processing techniques like milling, dehulling, soaking, germination, fermentation and cooking. These processing techniques not only save time, energy and fuel but have several nutritional advantages and produce edible products having a higher nutritional value and lower toxic compound. The degrees of elimination of toxic compound depend on type of pulses and the processing technique. Culturally relevant *P. vulgaris* species such as pinto, dark red kidney and black beans attenuate the glycemic response to rice, a commonly consumed high glycemic index food. [11]

Ayurvediya perspective

In *Ayurveda* mainly *Kashaya Tikta dravyas* (astringent and bitter taste drugs) have been indicated in *Meha rogas* due to the predominance of *Meda dhatu*. Different *sanskaras* (transformations) can be used in different *Katu Tikta* and *Kashaya dravyas* for different causes and stages of *Meha rogas* (diabetes and disorders alike), according to the respective vitiation of *Doshas* like

Strotoshodhana (clearance of channels), *Meda dhatu dushti* (vitiation of fat substances), *Vata prakopa*, *aavaran* of *doshas* etc. Concept of treatment of diabetes in *Ayurveda* is revealed in *Sushruta Samhita* where *Shaali*, *Saathi*, *Jau*, *Kodo* (various types of cereals) are instructed to be taken along with the *VIKALAP* (alternatively changing combinations) of *Chanaka*, *Arhara*, *Kulattha*, *Mudga*, and *sanskrit* with the oils of *Danti*, *Ingudi*, *Sarshapa* and *Atsi* (flax seeds) along with *Shaaka varga* (green leafy vegetables) . [12] Also, in *Charaka Samhita*, *Mudga Yusha* (soup) has been told to be taken along with *puraana Shaali* (old grains) and *Tikta Dravya Shaaka* in *Kaphaja Prameha* (a subtype of Diabetes). [13]

Properties of Pulses (of use in Diabetes Mellitus), As Per The *Ayurvedic* Texts

Pulse	***Rasa* (taste)**	***Guna* (properties)**	***Virya* (potency)**	***Vipaka* (metabolic actions)**	***Doshaghnata* (effect on doshas)**	***Karma* (actions)**
***Arhara* (Pigeon pea, red gram)**	*Kashaya* (astringent), *Madhura* (sweet)	*Laghu* (light), *Ruksha* (dry)	*Sheeta* (cold)	*Katu* (bitter ~catabolic property)	*Kapha-pitta Shamaka* (alleviate *kapha* and *pitta dosha*)	*Varnya* (complexion promoting) *grahi* (both appetizer and digestive) *Shtaulyahara*, (weight gaining) *Pittatisaara nashaka* (Laxatives)
***Kulatha* (Horse gram)**	*Kashaya* (astringent)	*Laghu*(light), *vidahi* (burning sensation promoting)	*Ushna* (hot)	*Katu*(bitter ~catabolic property)	*Kaphavata shamaka* (alleviate *kapha* and *vata dosha*), *Pittarakta krita* (vitiates *pitta* and *rakta*)	*Grahi*(both appetizer and digestive), *ashmarighna* (stone lysis promoting), alleviates *Kasa* (cough) *Shwas*(breathlessness) *hikka* (hiccup) *Arsha* (haemorrhoids) *Medoroga* (obesity) *nashaka.*
***Chanaka* (bengal gram)**	*Kashaya Madhura*	*Laghu ruksha*	*Sheeta*	*Katu*	*Kapha-pitta-rakta shamaka* (alleviation), *Vata vardhaka* (vitiation), if given with *Ghrita* (clarified butter) - *Tridosha shamaka* (alleviates three doshas)	*Virukshana* (promoting dryness)
***Motha* (Moth bean)**	*Madhura*	*Ruksha laghu*	*Sheeta*	*Madhura* (sweet ~ anabolic property)	Alleviates *Kapha pitta*, vitiates *vata*	*Grahi*((both appetizer and digestive)
***Masura* (Lentil)**	*Madhura*	*Laghu, Ruksha*	*Sheeta*	*Madhura*	*Kapha pitta shamaka, vata vardhaka*	*Raktapitta hara* (alleviates blood clotting related disorders), *Jwaraghna* (alleviates fever), *Grahi*
***Mudga* (Green gram)**	*Kashaya Madhura*	*Vishada* (non slimy) *Laghu, Ruksha*	*Sheeta*	*Katu*	Alleviates *Kapha pitta*	*Chakshushya* (eye health promoting), *Grahi, Jwaraghna*

Therapeutically Useful Properties of Pulses from the point of view of Managment of DM

Aadhaki (Pigeon pea, red gram)

Commonly known as *arhar* and *tuvari* with the botanical name *Cajanus cajan* (Linn) Millsp and family *Fabaceae*, *Aadhaki* has been described as *Kapha pitta shamaka* (astringent and sweet taste), with the properties of *Kashaya madhura ras*, *Ruksha Laghu guna* (dryness and lightedness), *Sheeta virya* (cold potency) and *Katu vipaka* (~ catabolic actions) which are ideal to suit the increased *Kapha* and *Meda* (fat) condition of *Prameha* patient and will be helpful in fighting obesity. [14, 15] It has been told to be used in the form of *Yusha* (soup). This food is very low in Saturated Fat, Cholesterol and Sodium. It is also a good source of protein and copper, and a very good source of dietary fiber, folate and manganese.

The effect of roasted and unroasted seeds of C. cajan on serum glucose levels of normal and alloxan diabetic mice were studied. Single doses of unroasted seeds (60% and 80%) on administration to normal as well as alloxanized mice showed significant reduction in the serum glucose levels after 1-2 hr and a significant rise at three hours. In case of roasted seeds, on other hand there was a significant increase in serum glucose levels during the three hour experimental period. It was therefore concluded that roasting of seeds at high temperature for an half hour period resulted in the total loss of hypoglycemic principle but not the hyperglycemic principle present in the seeds. [16]

Kulattha (Horse gram)

Commonly known as *Kulthi*, this plant is botanically *Macrotyloma uniflorum* (Lam.) Verdc and belongs to the family Fabaceae. It has been indicated as *Pathya* in *Prameha* (Diabetes and its subtypes) by *Acharya Sushruta*. [12] It has *Kashaya rasa*, *Laghu vidahi guna*, *Ushna virya* and *Katu vipaka* which makes it *Kapha vata shamaka*, *Ashmari nashaka* (anti colic and anti urolithiatic), and useful in *Kasa*(cough), *Hikka* (hiccough), *Shwasa Roga* (breathlessness and respiratory disorders). [17, 18] The main chemical constituents identified were mome inositol, ethyl alpha-d-glucopyranoside, n-hexadecanoic acid, linoleic acid (9, 12-octadecadienoic acid), its esters and ethyl derivatives, Vitamin E, stigmasterol and 3-beta-stigmast-5-en-3-ol.

Scientists from the Indian Institute of Chemical Technology, Mumbai have found that unprocessed raw horse gram seeds not only possess antihyperglycemic properties, but also have qualities which reduce insulin resistance. The scientists made a comparative analysis between horse gram seeds and their sprouts and found that the seeds have greater beneficial effects on the health of hyperglycemic individuals. The majority of antioxidant properties are confined to the seed coat and its removal would not do any good. Raw horse gram seed is rich in polyphenols, flavonoids, and proteins, major antioxidants present in fruits and other food materials. The seed has the ability to reduce postprandial hyperglycemia by slowing down carbohydrate digestion and reducing insulin resistance by inhibiting protein-tyrosine phosphatase 1 beta enzyme. [19]

D. biflorus at doses of 300 mg/kg/day for 30 days resulted in gradual but significant decreased diabetic nephropathy stz induced diabetes rats. [20] It also have been experimentally proven to have anti-lipidemic and anti-oxidant properties. [21, 22]

Chanaka (Bengal gram)

Commonly known as *Chana*, with latin name *Cicer arietinum* Linn and family Fabaceae, this pulse is *Kashaya madhura*

in its *Rasa*. It has *Laghu ruksha guna*, *katu vipaka* and *Sheeta virya.* [23, 24] Hence it is *Kapha-pitta-rakta shamaka* and if taken along with *sanskarita* ghee (clarified butter processed with medicinal plants), will be *Vata shamaka* also. Its overall *Prabhava* (metabolic effect) is *Virukshana* (drying~ catabolic action in the body) and hence can be told as a *Pathya shami dhanya* (appropriate or indicated pulse diet) in diabetes. It should be used in the *Kalpana* (preparations) of *Yusha*, *Bhrishtha* (roasted form) and powder.

PEECA (petroleum ether extract of *Cicer arietinum*) showed antihyperglycaemic activity comparable with glyburide. It has been reported that vanadium-enriched chickpea sprout ameliorated hyperglycemia and impaired memory in streptozotocin-induced diabetes rats. It has been shown that increased antioxidant and inhibitory potential of sprouted Bengal gram (chick pea) against α-glucosidase and α-amylase makes them desirable for dietary management/prevention of diabetes. Total saponins from chick pea reportedly demonstrated renal protection when administered to type 2 diabetes mellitus rats (Kaiser et al., 2012). An antioxidant-rich extract of chick pea and its sprouts reportedly mitigated starch-induced postprandial glycemic spikes in rats. [25]

***Makushtha* (Moth bean)**

Commonly known as moth, *Vigna aconitifolia* (Jacq) Marechal, belongs to the family Fabaceae is *Madhura rasa*, *Sheeta virya* and *Madhura vipaka dravya* (~anabolic action), [26] which explains its *Jeevaniya shakti* (nutritive property) in diabetes. It has *Laghu ruksha guna* (light and dry properties) which will not allow any kind of *Meda* or *Kapha vridhhi* (fat deposition metabolism). It meets the ideal condition of the patients in which we have to increase the *Bala* (energy level) of the patient without increasing the fat content (~*Meda dhatu*). It has *Kapha pitta* alleviating property which is beneficial for the patient of diabetes and hence this pulse is *Pathya* in diabetes.

Treatment with hydroalcoholic extract of *Vigna aconitifolia* significantly reduced elevated blood glucose, AUC glucose levels and also showed significantly reduced serum CPK-MB, LDH, creatinine and blood urea nitrogen levels in diabetic rats which indicated anti-diabetic activity and protective action of drug in heart and kidney complications in diabetic rats. The seed of *Vigna aconitifolia* possess significant antihyperlipidemic activity as it also lowers serum cholesterol and triglycerides levels in experimental study on rats. Thus it can be concluded that hydroalcoholic extract of *Vigna aconitifolia* seed possess anti-diabetic activity and it also helpful in management in diabetic complications. [27]

***Masura* (Lentil)**

Commonly called as *Masura* or *Masuri*, *Lens culinaris* also belongs to the family fabaceae. It is also *Madhura rasa, Madhura vipaka* and *Sheeta virya dravya* but has *Laghu ruksha guna* thereby promoting the energy level in the body without increasing the *Kapha meda bhavas* (properties). It should be ideally used in the form of *Yusha* and *Bhrishta* (roasted form). [28, 29]

In a meta-analysis of eleven clinical trials that examined the effects of pulses on serum lipoproteins, results revealed that intake of non-soya pulses, including lentils, was associated with reduction in fasting serum total cholesterol (TC), lipoprotein cholesterol (LDL), triglycerides (TG) and an improvement in high density lipoproteins (HDL) cholesterol. The reviewers ascribed the hypocholesterolemic effects of pulses to be related, in estimated order of importance, to soluble dietary fiber, vegetable protein, oligosaccharides, isoflavones, phospholipids and fatty acids, saponins and other factors. [30] The administration of lentils significantly increased HDL-cholesterol in diabetic rats. [31]

***Mudga* (Green gram)**

Mudga, commonly known as *Munga*, is botanically *Vigna radiata* of the family fabaceae. It is *Kashaya madhura* in *rasa*, [32, 33] *Vishada* (non slimy), *Laghu*, *Ruksha* in *guna* and has *Katu vipaka* hence cited as *Pathya* in diabeties. It is *Chakshushya* (tonic for eyes) in *Karma* so can be supplemented in diet of the patients to reduce the chances of diabetic retinopathy. It can be supplemented in the forms of soup, sprouts, *Papada* (chips), *Laddu* (sweets) and roasts.

Studies have also investigated the antidiabetic effects of *munga* bean extracts. In a study conducted in 2008, the antidiabetic effects of *munga* bean sprout extracts and *munga* bean seed coat extracts were investigated in type 2 diabetic mice (male KK-A^y mice and C57BL/6 mice). These extracts were orally administered to KK-A^y mice for 5 weeks, and *munga* bean sprout extracts (2 g/kg) and *munga* bean seed coat extracts (3 g/kg) lowered blood glucose, plasma C-peptide, glucagon, total cholesterol, triglycerides, and blood urea nitrogen (BUN) levels. At the same time, both treatments markedly improved glucose tolerance and increased insulin immune reactive levels. [34]

DISCUSSION

Legumes are normally consumed after processing, which not only improves their palatability but also reduces certain toxins and increases the bioavailability of nutrients, by inactivating phytic acid, trypsin inhibitors, and hemagglutinins, although resulting in some loss of water-soluble nutrients. [35] Inclusion of legumes in the daily diet has many beneficial physiological effects in controlling and preventing various metabolic diseases such as DM.

Along with their nutritional value, the pulses as indicated in *Ayurvediya* texts, also have much therapeutic potential owing to their *Kashaya rasa*. *Kashaya rasa* of pulses is due to the presence of high molecular weight polyphenols or Tannins. These tannins are responsible for the hindrance of the absorption of starch from the cereals if taken along with them. [36] Also, the antinutrition properties of pulses explain their utility in diabetes in modern

science concept. Antinutrition factors present in pulses result in increased bioavailability of minerals and vitamins thereby being beneficial to the body on consumption as food.

Pulses indicated as *Pathya* in DM have *Madhura vipaka* and *Kashaya tikta rasa* mainly thereby decreasing the *Kapha dosha*, but promoting the energy and vitality in the diabetic patients owing to its *Madhura vipaka*. Processing with mustard/linseed oil as prescribed in texts, further improves the taste, reduces *Vata* and *Kapha dosha*, hence beneficial in the DM.

These pulses are also well proven in modern science as having antihyperglycemic along with antioxidant activity. Application of these pulses in diabetes is due to the tannins, saponins and ant nutrients present in these pulses. Tannins are useful in diabetes in many ways; they hinder the absorption of starch in small intestine, reducing the amount of food intake because of the carbohydrate and protein content, and by directly affecting the beta cells also. In addition, the outer coat of the pulses is a good source of minerals and the food fiber hence is useful in diabetes.

CONCLUSION

Proteins in vegetarians are primarily achieved by pulses. The pulses are good sources of essential amino acids, and if vegetarians consume it with rice , it can help in meeting the needs of various amino acids.

Pulses indicated in diabetes by *Acharyas* like *Tuvri*, horse grass, *Munga*, lentil and *Makushtha* are *Kashaya rasa*, have *Laghu ruksha guna* and *Kapha shamaka* property. All the pulses are *Kashaya* and hence *Vata vardhaka* and hence their intake should be done in *Sanskarita* form with *Sneha varga* (saturated and unsaturated fats) so that they do not aggravate *Vata* in body.

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