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THERAPEUTIC POTENTIAL OF SOME INDIGENOUS FOOD GRAINS IN THE MANAGEMENT OF DIABETES MELLITUS TYPE-II

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Abstract: *Diabetes mellitus type-II (DM-2) is a global health challenge of the present era. The disease is a group of metabolic disorders in which high blood sugar level persist over a prolonged period. It develops primarily due to altered life style factors including high sugar intake, low dietary fibers, high body mass index and lack of physical activity. In Ayurveda the disease Prameha (Diabetes) has mentioned as Apathya Nimittaja (unwholesome dietary habits) and indicated as life style disorder thousands of years ago. Acharya Charaka and Sushruta have prescribed some indigenous food grains as Pathya (wholesome diet) in the management of Prameha. Present study aims to explore the some therapeutic potential rich indigenous food grains in the management of DM-2. Sanwa (Echinochloa frumentace Linn.) and Kodo (Paspalum scrobiculatum Linn.), these millets are extensively used in Ayurvedic classics for Prameha. All the systems of medicine have much stress on dietary changes in the management of DM-2. A dietary guidelines by World Health Organization (WHO) for diabetics, recommends low carbohydrate, high antioxidant and fiber rich diet in daily meals. Incidence of DM-2 is lower in population of rural areas and tribal belt which might be due to use of indigenous food grains (minor cereals and millets). Millets are unique food grains which are rich in protein, fibers, minerals, antioxidants and trace elements. They are the only food grains which are capable of combating all metabolic disorders.*
Keywords: *Metabolic disorders, Diabetes mellitus type-II, Life style disorders, Millets, Indigenous Food grains.*

Introduction: Diabetes mellitus type-II (DM-2) referred as NIDDM and is a group of metabolic disorders in which high blood sugar level persist over a prolonged period. Every 5 second one person is detected with diabetes and every 10 minutes dies with diabetic complications [1]. The condition has arisen by westernization of lifestyle, urbanization, with consequent dietary changes and obesity. Presently it is a global health challenge, and gradually affecting the large populations irrespective of the socio-economic conditions. It is very important to control diabetes and its complications to alleviate the human sufferings. The World Health Organization (WHO) has also substantiated the utilization of herbal remedies for the management and less adverse effects. Presently numerous medicinal plants have been reported to be effective in diabetes, but the situation is not improving yet, still further researches are needed. Human beings have been eating coarse grains (millets) since the development of civilization. The incidence of DM-2 is lower in a population with high fiber intake mostly in rural areas and tribal belt which might be due to use of minor cereals and millets with high fiber content. Millets are the only food grains which are capable of combating all metabolic disorders. As per Ayurvedic text the two indigenous food grains- *Sanwa* (*Echinochloa frumentacea* Linn.), *Kodo* (*Paspalum scrobiculatum* Linn.) are extensively used for *Prameha* (diabetes) [2-3]. But unfortunately India is at the top of the list in number of diabetic patients in spite of major producer of these potential grains.

Pathophysiology of Diabetes Mellitus: In NIDDM Patients are unable to respond to insulin and characterized by disturbed carbohydrate and fat metabolism. Its onset is mostly in adulthood and largely in obese people over 40 years of age. Recent studies indicate the bioactivity of free radicals in the pathogenesis of diabetes and its complications. Free radicals are responsible for damaging cellular molecules, proteins, lipids and DNA, leading to alteration of cellular functions. In diabetes free radicals oxidize the lipoproteins (VLDL, LDL, HDL). The abnormalities in lipid and protein metabolism are one of the key reasons for the development of diabetic complications. Different extracellular proteins are also modified into glycoproteins due to high blood glucose, which is associated with severe diabetic complications. Age, Stress, faulty Dietary habits, Malnutrition including deficiency of multivitamins and micronutrients play an important role in free radical production Vitamins C and E, the natural antioxidants, have been reported to decrease the oxidative stress in experimental diabetes [4].

Conventional vs. Alternative Treatment: The contemporary treatment of diabetes is focused on suppressing and controlling blood glucose to a normal level. As per metabolic disorder, the common line of management of type II diabetes is the transformation in lifestyle, appropriate diet and physical activity along with anti diabetic drugs. Nowadays there are many single and compound herbal and herbo-mineral formulations extensively used in Ayurvedic therapeutics. But the situation is still not improving. *Ayurveda* advocates *Pathya Aahar-Vihara* (wholesome diet & habits) in almost all disease. Recent studies suggest that dietary changes are new measures in the lowering of glucose and increased insulin sensitivity. *Sanwa* (*Echinochloa frumentace* Linn.), *Kodo* (*Paspalum scrobiculatum* Linn.) are widely used as a *pathya* (wholesome diet) in classics [2-3].

Classical Food Grains

Food grains	Bot. Name	Rasa	Guna	Therapeutic Uses
Sama (Barnyard millet)	*Echinochloa frumentace* Linn.	*Madhura,Kashaya*	*Sheet, Snigdha, Laghu*	*Medoroga(Obesity),Raktapitta(bleeding disorders),Pittaj kasa(yellow cough), Urustamha (spasticity of thigh), Stanyadosa(disorders of breast milk) , Jalodara(ascitis)* [5-6]
Kodo (Kodo millet)	*Paspalum scrobiculatum* Linn.	*Madhura, Tikta*	*Guru, Ruksha*	*As the* above [5-6]

Echinochloa frumentacea

Annual. erect, 30–150 cm long, Leaf-sheaths glabrous on surface, Ligule absent, Leaf-blades 10–30 cm long; Inflorescence – racemes, Spikelets in pairs, or clustered at each node. Fertile spikelets, sessile; 2–4 in the cluster. Glumes dissimilar; reaching apex of florets; Caryopsis exposed between gaping lemma and palea at maturity [7].

Paspalum scrobiculatum Linn.

A wild, annual grass, decumbent ascending culm and rooting at nodes. Leaves-linear lanceolate white-margined, upto 1cm broads with compressed sheath. Racemes: 2-5, subdigitate, in 2-seriate spikelets [7].

Nutritional Profile of Food Grains

Food grains	Carbohydrate(g)	Protein (g)	Fat (g)	Energy (kcal)	Fiber (g)	Mineral (g)	Ca (mg)	P (mg)	Fe (mg)
Kodo millet	65.9	8.3	1.4	309	9.0	2.6	27	188	0.5
Barnyard m.	65.5	6.2	2.2	307	9.8	4.4	20	280	5.0
Barley	77.7	9.9	1.2	352	15.6	-	29	221	2.5
Wheat	71.2	11.8	1.5	346	1.2	1.5	41	306	5.3

Source: Nutritive value of Indian foods, NIN, 2007

Sama (Barnyard millet) *(Echinochloa frumentace* Linn.)

Phytochemistry: The amino acid composition of seed found as aspartic acid (0.522%), lysine (0.046-0.047%). Other amino acids as glutamic, methionine, L-ornithine , alanine, arginine, DL-tryptophan, serine, glycine, proline, valine, threonine, tyrosine, phenylalanine, leucine, L-hydroxyproline, isoleucine. Seeds are lacking in cystine, histidine, 2-aminobutaric and L-cysteine amino acids. The saturated fatty acid, caprylic acid (2.1%), palmitic acid (17.1%), stearic acid (6.1%) -(5.0%), arachidic acid(1.1%)%), bahenic acid(0.3% - 0.4%). The total saturated fatty acid (TSFA) content (24.2%-26.0%). The unsaturated fatty acid are Oleic acid (29.5%) (MUFA), linoleic acid (46.9%), linolenic acid (1.0 %) and ecosanoic acid(0.5%) [8].

Antidiabetic Activity: A study was carried on anti-diabetic and hypo-lipidemic activity of the hydro-alcoholic extract of E. frumentacea (HAEF) in experimental diabetic-induced rats for 21 days. Diabetes was induced by ALX (120mg/kg, I.P.) and three different doses (200, 400 and 600mg/kg, P.O.) of HAEF were administered orally and activity studied for 12 hours. Glibenclamide (5mg/kg P.O.) was used as reference standard. High dose of HAEF (600 mg/kg, P.O.) showed a maximum decrease in blood glucose levels at 12th hour compared to the normal group. The fasting blood glucose levels decrease in glibenclamide, along with HAEF high dose and medium dose treated rats. Low dose shows reduced activity at 150 min. The possible mechanism of lowering of glucose levels is the inhibition of intestinal absorption and may be potentiating the secretion of insulin and increase the utilization of glucose in muscles. Oral glucose tolerance test was performed on normal rats and ALX induced diabetic rats. High dose (600 mg/kg, p.o.) and medium dose of HAEF (400 mg/kg, p.o.) showed maximum tolerance of glucose at 120 minutes significantly as compared to the diabetic control. This hypoglycemic activity may be due to the stimulation of surviving β-cells to release more insulin and inhibiting hepatic gluconeogenesis or inhibiting α-glucosidase enzyme in the intestine, which is the enzyme helpful for breakdown of disaccharides to form glucose. Induction of diabetes with ALX is associated with a characteristic decrease in body weight than the normal rats, this may be due to the wasting and loss of tissue protein. Whereas, diabetic rats treated with 200, 400 and 600mg/kg, p.o. of HAEF showed an improved result when compared with normal diabetic control, which may be due to the protective effect in controlling muscle wasting by reversal of gluconeogenesis and may also be due to the improvement of glycemic control [9-10].

Hypolipidemic Activity: The serum cholesterol and serum triglyceride levels of the normal rats were found to be increasing within the normal range during the four weeks of study period. Under normal condition, insulin activates enzyme lipoprotein lipase and hydrolyses triglycerides. Insulin deficiency results in failure to activate the enzymes thereby causing hyper triglyceridemia. This altered lipid metabolism leads to diabetic complications. Diabetic rats treated with the medium, high dose of (400 and 600mg/kg, p.o.) HAEF and Glibenclamide have shown a significant decrease in the levels of TG, TC, LDL-C and VLDL-C, whereas it increases the levels of HDL-C when compared to the normal diabetic control rats [10].

Antioxidant Activity: Superoxide dismutase (SOD) is an enzymatic antioxidant which reduces superoxide radical to hydrogen peroxide and oxygen. A decrease in the antioxidant activity in liver results in the accumulation of free radicals (hydroxyl radical) in diabetic rats. Administration of the high dose, medium dose, low dose of HAEF (200, 400 and 600 mg/kg, p.o.) and glibenclamide increased the activity of SOD levels to a significant level of $P<0.001$. While the SOD levels of untreated diabetic control rats having lowered levels. The *Echinochloa frumentacea* may act by either directly scavenging the reactive oxygen metabolites or by increasing the antioxidant molecules. In diabetes, lipid peroxidation is one of the characteristic features of chronic diabetes. The increased free radicals react with the polyunsaturated fatty acids in cell membrane leading to lipid peroxidation and in turn development of free radicals. Low levels of lipoxygenase peroxides stimulate the release of insulin. Glutathione which is a tripeptide normally present at high concentrations intracellularly. Glutathione (GSH) is helpful for reducing the toxic effects of lipid peroxidation. Decreased level of GSH in the liver during diabetes represents its increased utilization due to oxidative stress. Significantly increased levels of GSH were shown in the diabetic rats treated with the high dose, medium dose, low dose of HAEF (200, 400 and 600 mg/kg, p.o) and glibenclamide [10].

Kodo millet (Paspalum scrobiculatum Linn.)

Phytochemistry: Quercetin was the main flavonoid present. Five phenolic acids found-vanillic acid, syringic acid, cis-ferulic acid, p-hydroxy benzoic acid and melilotic acid. Total phenols were 1.120 mg/g in terms of gallotannins. Kodo millet yielded 0.856% of a clear yellow fatty oil which contains esters of four major fatty acids, i.e. oleic acid, stearic acid, palmitic acid and linoleic acid. Saturated fatty acids were more in amount to 57% consisting of stearic acid (37.5%) and palmitic acid (19.5%). Though oleic acid was maximum amounting to 40.7%, the other unsaturated acid, linoleic was only 1.57%. Phospholipids present in the grain were 0.24%, consisting of four bands of cephaelins, two bands of lecithin and a single band of galacto lipid [11].

Antidiabetic Activity: The antidiabetic property of kodo millet is mainly dependend on phytochemicals. Quercetin, the main flavonol present in this millet, possess many pharmacological properties including anti-diabetic action. An in vitro study was carried and proved that quercetin can reduce intestinal glucose absorption at the level of glucose transporters, block tyrosine kinase, potentiate both glucose and glibenclamide induced insulin secretion, and protect β-cells from oxidative damage induced by H_2O_2, inhibit glucose uptake, improve glucose homeostasis [12-15]. A in vivo study was carried and showed multiple way of activity of quercetin such as- (a) Inhibition of small intestine maltase, (b) Increased glucokinase activity and an increase in the number of pancreatic islets, (c) Partially preventing degeneration of β-cells, (d) Alleviate diabetic symptoms and liver injury and (e) Improve insulin sensitivity. It is also revealed that quercetin rich food is more effective than pure quercetin in controlling diabetes [11,16-17].

Anti-obesity: Another important role of quercetin that is being followed up of late is its role in obesity. It is proved to reduce triacylglycerol content, inhibition of lipogenesis, inhibit lipoprotein lipase, activate lipase and thus increase lipolysis, increasing apoptosis, reduce body weight and decrease oxidative stress [18].

Anti Diabetic Neuropathy: Recently, vanillic acid is established to contribute to the prevention of the development of diabetic neuropathy by blocking the methyl glyoxal-mediated intracellular glycation system. Syringic acid as well as vanillic acid increased cell viability and decreased apoptosis of cells, among other effects when exposed to methyl glyoxal. They worked as inhibition of the p38 MAPK (mitogen-activated protein kinases) path-way and prevents apoptosis of the Schwann cells [17].

Antioxidant Activity: All the above mentioned phenolics are highly active antioxidants. The role of antioxidants in human diet is being increasingly felt these days. Since it is understood that all the chronic diseases like diabetes, cancer, stroke, atherosclerosis etc are caused either by the reduced levels of antioxidants in the body or the increased levels of free radicals. The five phenolic acids present in Kodo millet is vanillic acid, syringic acid, cis-ferulic acid, p-hydroxy benzoic acid and melilotic acid. Except melilotic acid all have found antidiabetic properties and ferulic acid is most active. Ferulic acid is found to exert protective and therapeutic effects on diabetic nephropathy by reducing oxidative stress and inflammation [19]. A study carried by supplementation of this phenolic acid to the food of diabetic rats resulted in a decrease in the levels of glucose, TBARS (thiobarbituric acid reactive substances), hydroperoxides, FFA (Free fatty acids) and an increase in reduced glutathione (GSH). It is proved that administration of ferulic acid helps in enhancing the antioxidant capacity of these diabetic animals by neutralizing the free radicals and reducing the intensity of diabetes [20]. Another study carried on addition of ferulic acid at 0.01% and 0.1% of basal diet showed to suppress significantly blood glucose levels in STZ-induced (streptozocin) diabetic mice. These findings suggest that dietary ferulic acid is useful in alleviating oxidative stress and attenuating the hyperglycemic response associated with diabetes [18].

Conclusion: It is evident that diabetic diet should be low in simple carbohydrates, more fiber, more antioxidants and micronutrients. These two grains possesses all the required contents. Ayurvedic classics advised these grains thousands of years ago. Recent researches proved antidiabetic, antiobesity, hypolipidaemic, antioxidant properties of these grains and makes them "*Antidiabetic grains*". These grains contain proteins with high digestibility, low carbohydrate with low digestibility, more insoluble fibers and phytochemicals which are also useful in diabetic complications and other degenerative disorders. Further researches are needed for the global acceptance of these indigenous grains as dietary substitutes in diabetics.

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