Invigorated barley in diabetes

Ashok K. Tiwari

With over 41 million diabetics, India has become diabetes-capital of the world. The country is also a leader in the prevalence of metabolic syndrome and obesity, with hypertension to join the list soon. Historical evidences suggest that the ancient Indian physicians were able to stabilize diabetes, obesity and related metabolic syndrome effectively through recommendations, which are not different from those given today to patients, like weight management, suitable diet and exercise. Dietary management in diabetes has always been amongst the key strategies. Some 2800 years ago, the ancient Hindu physician, Charaka had identified barley as a low glycemic-dietary substitute for diabetes patients. He also advocated different invigorating agents like honey, triphala and vinegar for use with barley-based diet and drink. This article presents scientific evidence for the genuineness of selection of barley as a dietary substitute and inclusion of other fortifying agents in barley-based diet and drink.

Keywords: Barley, diabetes, hypertension, invigorating agents, obesity.

DIABETES mellitus is a serious global health problem that significantly affects a person's quality of life and life-span. With over 41 million diabetics and every fifth diabetic in the world being an Indian, the country is the diabetes capital of the world[1]. It is also leader in the prevalence of metabolic syndrome as well as obesity, with 20 million people being either obese or abdominally obese[2]. It has been observed that the real impact of diabetes and obesity is through hypertension and cardiovascular disease. Unfortunately, India being a world leader in diabetes is also heading towards hypertension[1].

Modern scientific understanding about the driving forces for the current worldwide epidemic of diabetes finds environmental factors such as adoption of a sedentary lifestyle, changes in eating habits and the consequent obesity as the main factors[3]. This hypothesis is supported by observations that prevalence of diabetes in urban regions of India is increasing dramatically in affluent migrants[4]. These modern scientific observations and understanding of diabetes are not different from those mentioned thousands of years ago in Ayurvedic literature[5].

The science of life, Ayurveda, which evolved in ancient India[6], was designed not only to treat diseases, but also emphasized the ways to prevent and manage long-term chronic health problems. The ancient Indian physicians were able to stabilize diabetes effectively, type-II diabetes in particular, by advocating weight loss, dietary formulations and exercises like in the case of modern medicine. In the case of diet, barley (यव, *yava – Hordeum vulgare* Linn.), one of the oldest cultivated grains[7] found prime importance as a substitute for other foodgrains. More than 2800 years ago[8], the Indian physician Charaka mentioned that 'use of parched barley grains and its flour (सक्तू, Sattoo) prevents the development of diabetes' according to the verse 'भृष्टान यवान् भक्षयतः प्रयोगाच्छुष्कांश्च सक्तून भवन्ति मेहाः' (Ch.Chi.6.48) from *Charaka Samhita*[9]. Charaka advocated, 'use of barley and goose berry (आवंला, amala) powder as the best remedy for obesity', according to the verse 'स्थौल्ये यवामलक चूर्णश्च प्रयोगः श्रेष्ठ उच्यते' (Ch.Su.21.23)[9]. However, these remedial treasures and measures from Ayurveda could not surface at the modern international scientific platform in order to maximize their potential contributions to the health care system globally.

This article highlights the methods for preparation and use of barley-based diet and drink as mentioned in *Charaka Samhita* for diabetics, provides modern scientific evidences for the genuineness of selection and the inclusion of other fortifying ingredients along with barley, and possible reasons for the failure of these ancient Indian medical contributions at the international scientific platform.

Use of barley in diabetes as described in *Charaka Samhita*

The verse 'सषष्टिकं स्यात्तृणधान्यमन्नं यवप्रधानस्तु भवेत् प्रमेही. यवस्य भक्ष्यान् विविधांस्तथाध्यात् कफप्रमेही मधुसंप्रयुक्तान' (Ch.Chi.6.21)[9] mentions that 'the diet of diabetic patients should consist predominantly of barley, wherein various food items should be prepared along with different wild varieties of rice. In the primary stages of diabetes development, a person should take honey also along with various food items prepared with barley'. *Charaka Samhita*[9] also describes a drink for diabetics. According to the verse:

Ashok K. Tiwari is in the Pharmacology Division, Indian Institute of Chemical Technology, Hyderabad 500 007, India.
e-mail: tiwari@iict.res.in

'निशिस्थितानां त्रिफ़लाकषाये स्युस्तर्पणाः क्षौद्रयुता यवानाम्. तान् सीधुयुक्तान् प्रपिबेत प्रमेही प्रायोगिकान्मेहवधार्थमेव' (Ch.Chi.6.22), the drink should be prepared as follows: 'dehusked, pounded and parched barley should be soaked overnight in the decoction of triphala (त्रिफ़ला). Diabetic patient should drink the slurry made up of this triphala-impregnated parched barley along with vinegar (सीधु–सिरका)'.

It is noteworthy to mention here that triphala is an Ayurvedic preparation made up of the mixture of three fruit powders, namely harad (हरड, हरीतकी, *Terminalia chebula*), bahera (बहेरा, विभीतकी, *Terminalia belerica*) and amala (आवंला, *Emblica officinalis*). According to the Ayurvedic classic *Sharangadhar Samhita*[10], in order to prepare triphala powder, one should take one fruit of harad, two of bahera and four of the amala as described in the verse: 'एका हरीतकी योज्या द्वौ च योज्यौ बिभीतकौ. चत्वार्यामल–कान्येवं त्रिफलैषा प्रकीर्तिता' (Sha.M.6.9) 10. Triphala itself is mentioned in this text to 'calm polyurea (मेह), inflammation (शोथ) and a kind of fever (विषम ज्वर)' according to the verse: 'त्रिफला मेहशोथघ्नी नाशयेद्विषमज्वरान्' (Sha.M.6.10)[10].

A thick bread called littee (लिट्टी), small round/oval-shaped Battee (बट्टी) and staple food like khicharee (खिचड़ी) are some of the common traditional Indian food items prepared with barley as the main ingredient. Littee is prepared by baking a thick dough of barley flour. Battee is special fast-food preparation of the northern part of India. It is prepared with barley flour dough. The dough of required quantity is first made in the shape of a bowl filled with dry, parched flour of black gram in particular, premixed with spices like ginger, garlic, mustard and mango powder, closed and then baked brown. The staple food Khicharee is cooked in water, particularly by boiling two parts of wild rice with one part of ground barley grain. Whole parched barley grain is also used as munching snack. The drink prepared with parched flour called Sattoo (सत्तू) is famous in the northern part of India and is still prescribed by local physicians to diabetes patients. It is prepared by making a slurry of parched barley flour (50 g) in a glass of water (250 ml). Different tasty additives like vinegar (one teaspoonful) or a pinch of sour paste made up of unripe mango and mint are also added into this slurry in order to make it tasty.

Scientific proof of antidiabetic properties of barley, honey, triphala and vinegar

Barley and its various products have been reported to possess preventive and therapeutic antidiabetic properties, both in experimental animals and clinical studies. Table 1

Table 1. Effect of barley diet/products on various parameters in diabetes

Study type	Barley diet/product	Observations	Reference
Animal			
Adult diabetic rats	Diet containing barley	Reduced blood glucose level, water consumption and weight loss	23
STZ diabetic rats	Barley substituted diet	Reduced plasma 7-S-collagen and lamin P2, modulation of altered glucose metabolism and basement membrane	24
Spontaneously diabetic G-K rats (3–9 months feeding study)	Barley diet	Reduced fasting plasma glucose, improved glucose tolerance, improvement in plasma total cholesterol and triglyceride levels, decrease in systolic blood pressure and lipid profile levels	25–27
Genetically diabetic mice [C57BL/Ks (–) m (+/+) Lepr (db)]	Malted barley extract	Alleviation of many symptoms of diabetes	28
Human			
Healthy volunteers and NIDDM patients	Barley bread	Low glycemic index and high insulinemic index	29
Healthy subjects	High-fibre barley genotype with elevated β-glucan levels	Significant improvement in glycemic and insulinemic indices	30
Type-II diabetic men	Waxy, hull less barley bread products	Improved glycemic response, increased insulinemic response, reduced dependence on oral hypoglycemic drugs	31
NIDDM diabetic subjects	Pearled and whole barley bread	Improved impaired carbohydrate and lipid metabolism	32
Healthy volunteers	Prowashonupana cultivars of barley	Absorption less than other cultivars, appropriate diet for obese and diabetic patients	33
Mildly hypertensive men (a randomized controlled crossover study)	Barley β-glucan-based diet	No significant change in total cholesterol, HDL-cholesterol, triglycerides nor in fasting and postprandial blood glucose level	34
Non-diabetic normal control and diabetic patients	Prowash – a barley-based breakfast	Reduction in postprandial glycemic peak with better insulin response	35
Lean healthy men	Barley β-glucan-based diet	Reduction in glycemic and insulinemic response	36
Type-II diabetes patients	Barley-rich food preparation	Overall metabolic improvement in patients	11

Table 2. Activity of triphala and ingredient activities in diabetes

Plant	Sample type	Experimental protocol	Observations	Reference
Triphala churna	75% methanol extract	Alloxanized diabetic rats, 100 mg/kg body wt dose of the extract	Homogeneous hypoglycemic activity, antioxidant activity	16
Terminalia chebula	$CHCl_3$ extract of seed powder	STZ diabetic rats fed with 100–300 mg/kg dose p.o. for up to 8 weeks	Dose-dependent reduction in blood glucose level, Reno protective property	37
	EtOH extract of fruit	STZ diabetic rats fed for 30 days, 200 mg/kg p.o	Control over alteration in TBARS, hydroperoxides, enzymatic and non-enzymatic antioxidants, decrease in blood glucose and glycated haemoglobin levels, comparable effect to glibeclamide, reduction in blood glucose and glycated haemoglobin level, insulin-stimulating action, normalization of carbohydrate and glycogen metabolizing enzymes, altered morphological changes in mitochondria and endoplasmic reticulum of pancreatic B-cell	38, 39
	Water extract	STZ diabetic rats on two weeks at 200 mg/kg p.o. dose	Increase in number of secreting granules of pancreatic B-cell, improved glucose tolerance, reduction in fasting blood glucose level	40
	Aqueous methanolic extract	*In vitro*	Inhibition of rat intestinal maltase in non-competitive manner, but not sucrase and isomaltase. Chebulanin, chebulagic acid, and chebulinic as active principles.	41
Emblica officinalis	Aqueous extract and constituent tannoids	STZ diabetic rats, 35 mg/kg i.p. for 8 weeks	No improvement in STZ-induced hyperglycaemia, delayed cataract progression, reversal of changes with respect to lipid peroxidation, protein carbonyl content and activities of antioxidant enzymes, prevention of aggregation and insolubilization of lens proteins caused due to hyperglycaemia.	42
	Commercial enzymatic extract and a polyphenol-rich fraction	STZ diabetic rats fed for 20 days, dose of 20–40 mg/kg body weight	Free-radical scavenging activity, inhibition of the production of advanced glycation end-products, improvement in body weight gain, alleviation of various oxidative stress indices in the serum, reduction in serum level of 5-hydroxymethylfurfural and creatinine, TBARS, decrease in albumin level, improvement in serum adiponectin level.	43
	Aqueous extract and constituent tannoids	*in vitro*, AR inhibition, lens organ culture	Inhibition of rat lens and recombinant AR activity, prevention of sugar-induced osmotic changes in rat lens	41
Terminalia belerica	75% methanolic extract	Free-radical scavenging activity	Scavenges variety of free radicals, hypoglycaemic activity in single and multiple dose studies in alloxanized diabetic rats.	16

summarizes the animal experimental and clinical observations made with various preparations of barley. These studies indicate barley as a food substitute that has low glycemic index and also has the capacity of improving impaired carbohydrate and lipid metabolism in diabetic subjects. Mugimeshi (prepared by boiling rice and barley in the ratio of 7 : 3) is a Japanese staple food that finds similarity with Indian food preparation Khicharee. In a recent study it was observed that consumption of staple food Mugimeshi along with well-regulated lifestyle had beneficial effects on metabolic control in patients with type-II diabetes[11].

Charaka Samhita[9] emphasized that honey should also be taken along with various food preparations made up of barley. Animal experiments[12] and observations made in normal human volunteers, type-I diabetes patients[13], type-II diabetes patients[14], and in young adults with impaired glucose tolerance[15], showed that honey attenuates post-prandial hyperglycemic response and hence may serve as a suitable sugar substitute for diabetics.

While prescribing the drink made up of barley for diabetics, verses from *Charaka Samhita* mention that parched barley should be impregnated in triphala decoction overnight. The slurry made up of this triphala-impregnated barley should be taken mixed with vinegar. Table 2 presents evidences for the usefulness of triphala and its ingredient fruits in different diabetic conditions. Though *T. chebula*, *T. belerica* and *E. officinalis* have been reported to possess beneficial antidiabetic properties by various mechanisms, it was observed that the homogeneous hypoglycaemic activity could be achieved only by the use of *triphala*[16].

Vinegar ingestion has been found to significantly reduce postprandial fluxes in insulin in normal, insulin-resistant subjects and type-II diabetic subjects[17]. Increased hepatic glucose production, decreased utilization of glucose in skeletal muscle and adipose tissues are important features associated with type-II diabetes. The 'metabolic switch', 5′-AMP-activated protein kinase (AMPK) has been suggested to play an important role in glucose utilization and fatty-acid oxidation independent of the insulin-signalling pathway[18]. Acetic acid is the primary constituent of vinegar and is present in the amount of 3–5 g/100 g. Diet supplemented with acetic acid has been reported recently to lower plasma glucose level and Hb A1c in different diabetic animal models, reduce the expression of genes involved in gluconeogenesis and lipogenesis partly by regulating AMPK in liver of KK-A (y) mice, lower the expression of genes for glucose-6-phosphatase and sterol regulatory element binding protein-1 (SREBP-1) in rat hepatocytes[19]. These findings support the beneficial effects of vinegar in type-II diabetes and also its addition in the barley-based drink described in Ayurveda.

Conclusion

Moran[20] observed that the ancient Greeks (AD 45–117) were the first to advocate diet and lifestyle management for individuals with diabetes. Unfortunately, he failed in finding records of the first-ever advocated medicinal fast food prescribed particularly for diabetic patients by the ancient Indian physicians, as discussed in this article. The reason maybe that during the transition phase of ancient India to the modern era, this knowledge could not get its due recognition, and the fact that hardly any modern scientific study could recognize and assess Ayurveda as a system of diagnosis and care[21].

Though individual ingredients as described in the Ayurvedic verses have been found to possess antidiabetic properties by modern scientific analysis, Ayurveda believes that the sum of a formula is more potent than the constituents individually[21]. In a recent study, it was observed that the traditional Oriental remedy, *Ginseng radix*, when processed with vinegar became more potent in decreasing insulin resistance and adiposity in metabolic syndrome induced by a high fat diet in ICR mice than the non-processed *Ginseng radix*[22]. Invigoration of triphala-soaked barley-based drink with vinegar, and addition of honey with barley-based dietary preparations as advocated in Ayurvedic verses may find scientific support from such reports. It becomes important in the light of the above discussions therefore, to make a retrospective analysis of our traditional medicinal foods in order to provide them sound scientific basis and modernize them according to the present requirements.

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