10.5005/jp-journals-10059-0052

REVIEW ARTICLE

Śākadravya (Vegetables) as Pathya in Metabolic Disorders—A Review from Classical Texts of Āyurveda with Current Evidences

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ABSTRACT

Aim: To review the vegetables mentioned as pathya for metabolic diseases like prameha/madhumeha, hṛdroga, and sthaulya from 15 different classical texts and to analyze the available data critically with the help of reported research activities to establish their role in the prevention and management of metabolic disorders.

Background: Metabolic syndrome is a multifactorial disorder, which can be prevented by changes in lifestyle and dietary habits. Among the preventive measures given for various disorders, the classical texts of Āyurveda describe all the vegetables along with their guṇa (properties), karma (action), and prayoga (indication) in different disease conditions under śākavarga. As diet is considered as the best preventive medicine, vegetables are indicated as pathya (wholesome diet) for metabolic diseases like prameha/madhumeha, hṛdroga, and sthoulya, and can be used in the prevention and management of metabolic disorders.

Review results: It is observed that among 318 vegetables mentioned in compiled texts, 29 vegetables are indicated in prameha/madhumeha and 33 vegetables are indicated in hṛdroga. Majority of these vegetables are reported for their anti-diabetic (18), anti-hyperlipidemia (14), cardio-protective (15), anti-hypertensive (7), and antiplatelet (5) activities.

Conclusion: Vegetables mentioned under śākavarga in classical texts of Āyurveda can be effectively used as pathya in metabolic disorders.

Clinical significance: On the basis of review results, further scientific studies can be planned clinically to evaluate the beneficial effects of these vegetables in clinical practice.

Keywords: Metabolic syndrome, Nutraceuticals, Pathya, Sākavarga, Vegetables.

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How to cite this article: Naik R, Borkar SD, Bhat S, Acharya R. *Śākadravya* (Vegetables) as Pathya in Metabolic Disorders—A Review from Classical Texts of Āyurveda with Current Evidences. J Drug Res Ayurvedic Sci 2018;3(3):181-193.

Source of support: Nil

Conflict of interest: None

INTRODUCTION

Metabolic syndrome is a disorder characterized by the combination of abdominal obesity, dyslipidemia, hypertension, and insulin resistance.[1] This condition is associated with an increased risk of cardiovascular diseases and diabetes mellitus as well as general morbidity and mortality.[2] Metabolic syndrome has multiple systemic involvements with non-alcoholic fatty liver disease, polycystic ovarian syndrome, and sleep and breathing disorders, etc.[3] As per the available literature in classical texts of Āyurveda, a set of disorders like prameha, sthoulya, hṛdroga, and medoroga can be collectively placed under the category metabolic syndrome.

Different risk factors such as metabolic and genetic components contribute to this emerging health problem.[4,5] Different studies also suggest that increased intake of red meat, fat, sodium, and inadequate use of vegetables and fruits may be the reasons associated with the increased prevalence of metabolic disorders.[6] The pathogenesis and progress of metabolic syndrome also have an association with dietary patterns and nutritional intake.[7–9] Therefore, there is a need for change in the dietary pattern and lifestyle, in order to prevent the manifestation of metabolic disorders.

Pathya (wholesome diet) is a unique concept in Āyurveda, which promotes the use of healthy dietary articles in the prevention and cure of different disorders. According to Āyurveda, proper nutrition/diet is the basic need for good health and also acts as a causative factor for diseases as well as preservation and promotion of health.[10] It is also said that in both the conditions, viz. health and disease, diet is a prime factor to be thought about, as it is said that, without proper diet, the use of any drug is futile.[11] Considering the importance of āhāra (diet), classical texts of Āyurveda categorized the dietetic items under various groups like dhānya

(grains), dugdha (milk), taila (oil), māṃsa (flesh), śāka (vegetables), etc.[12]

Particularly, authors of various classical texts of Āyurveda identified the health benefits of vegetables and dedicated a separate chapter or group. Due to the health benefits of vegetables, they should be regularly taken to cure or reduce the risk factors of metabolic disorders. Food supplements and prophylactic nutritional interventions may be developed based on leads from Āyurveda literature.[13] Therefore, a comprehensive analysis of the available literature in classical texts along with conventional studies could provide a lead in identifying the possible benefits of these vegetables. In the present review, vegetables delineated under śākavarga, used in the prevention and management of metabolic disorders, were compiled and presented along with their classical indications, properties, and pharmacological activities.

MATERIALS AND METHODS

Plants described under śākavarga, in different categories, like patra (leaf), puṣpa (flower), phala (fruit), nāla (stem) and kaṇda (tuber), were compiled from Charakasaṃhitā,[14] Suśrutasaṃhitā,[15] Aṣṭāngasaṃgraha,[16] Aṣṭāngahṛdaya,[17] and 12 different nighaṇṭu, i.e., Dhanvaṅtari nighaṇṭu,[18] Śoḍhala nighaṇṭu,[19] Mādhava dravyaguṇa,[20] Madanapāla nighaṇṭu,[21] Kaiyadeva nighaṇṭu,[22] Bhāvaprakāśa nighaṇṭu,[23] Rāja nighaṇṭu,[24] Priya nighaṇṭu,[25] Guṇaratnamāla,[26] Dravyaguṇa saṃgraha,[27] Dravyaguṇa śataśloki,[28] and Rājavallabha nighaṇṭu.[29] Published research articles and other books were referred to gather updated information to establish the role of these vegetables in the prevention and management of metabolic disorders. The obtained data are presented systematically with regards to their classical names, the part used, botanical identity, and reported research activity.

RESULTS AND DISCUSSION

Knowledge on the healing capacity of vegetables has been well explained in classical texts. Like other medicinal plants, vegetables have been reported for their medicinal values for the management and prevention of certain diseases. If these vegetables can be used as pathya (wholesome diet), and followed strictly, they may help to prevent as well as manage various diseases easily. Analysis of the results shows that classical vegetables are indicated for the prevention and management of diabetes, cardiovascular diseases, skin disorders, respiratory diseases, and gastrointestinal diseases. Recent studies also reveal that increased intake of important sources of dietary fiber like fruits, vegetables, legumes, and cereals is associated with positive health benefits. Particularly, dietary fiber, an integral component of vegetables, is useful in managing most of the metabolic disturbances linked with metabolic syndromes.[30,31]

The cluster of clinical conditions in the metabolic syndrome includes type 2 diabetes mellitus, dyslipidemia, hypertension, atherosclerosis, coronary artery diseases, etc. All these clinical conditions have been explained under prameha/madhumeha, hṛdroga, sthoulya, and medoroga in the classical texts of Āyurveda. These are considered as santarpaṇottha vikāra (diseases due to over nutrition) and can be prevented by following a proper diet and lifestyle. Different vegetables that can be used as pathya for metabolic disorders are given in Table 2 with their properties. Majority of these vegetables have tikta rasa, laghu and rūkśa guṇa properties(Table 1).

Vegetables in Diabetes

Vegetables are considered as the dietary sources of vitamins, minerals, and fiber and vegetables that have low amounts of carbohydrates are considered as the best dietary source. It is concluded by different studies that greater intake of green leafy vegetables is associated with a 14% reduction in risk of type 2 diabetes.[32] In the present review, it is observed that out of about 318 classical vegetables described under śākavarga, 29 vegetables are indicated as prameha/madhumeha. A review of published scientific studies also shows that 17 among these vegetables are reported for their efficacy in the management of diabetes and related complications.

Vegetables in Obesity

Overweight occurs if energy intake is higher than energy expenditure. Overweight and obesity predispose are associated with numerous cardiac complications such as coronary heart diseases and sudden death because of their impact on the cardiovascular system.[64] Compared to many other foods, the volume of vegetables in relation to the energy content is larger. Due to the favorable volume to energy ratio of vegetables, satiety signals can emerge without consuming a large amount of energy.[65] Epidemiologic studies support that dietary fiber is less linked to cardiovascular diseases and probably has a role in obesity prevention.[66] Different studies showed that an increase in vegetable and fruit consumption might be a suitable measure to facilitate initial weight loss and subsequent weight stability.[67] Among the classical vegetables of Ayurveda, which are indicated in prameha, hṛdroga, etc. 14 vegetables are reported for their anti-hyperlipidemic activity (Table 3).

Vegetables in Cardiovascular Diseases

The intake of vegetables is linked to a reduction in cardiovascular disease by a variety of ways. They provide

Table 1: Botanical identity, the part used and properties of classical vegetables indicated in prameha/madhumeha, hṛdroga, sthaulya, and or medoroga

S. no.	*Śāka*	*Botanical name*	*Part used*	*Rasa*	*Guṇa*	*Vīrya*	*Vipāka*
1	Alabu	*Lagenaria siceraria* (Molina) Standl.	Fruit	Tikta	Laghu	Śīta	Kaṭu
2	Arkapuṣpī	*Holostemma rheedianum* Spreng.	Leaf	–	Laghu	–	–
3	Brāhmī	*Bacopa monnieri* (L.) Wettst.	Leaf	Tikta, Kaṣāya	Laghu	Śīta	Madhura
4	Bṛhati	*Solanum indicum* L.	Fruit	Kaṭu, Tikta	Laghu	–	Kaṭu
5	Cakramarda	*Cassia tora* L.	Leaf		Rūkśa, Laghu	Śīta	–
6	Droṇapuṣpī	*Leucas cephalotes* (Roth) Spreng.	Leaf	Kaṭu, Lavaṇa	Guru, Rūkśa	Uṣṇa	Madhura
7	Eraṇḍa	*Ricinus communis* L.	Fruit	Kaṣāya	Snigdha, Uṣṇa	–	–
8	Gojihvā	*Launaea aspleniifolia* (Willd.) Hook.f.	Leaf	Kaṣāya, Tikta	Śīta	–	Madhura
9	Gṛñjana	*Daucus carota* L.	Tuber	Tikta, Madhura	Laghu, Tīkṣṇa	Uṣṇa	Madhura
10	Guḍucī	*Tinospora cordifolia* (Willd.) Miers	Leaf	Kaṣāya, Kaṭu, Tikta	Laghu	Uṣṇa	Madhura
11	Kākamāci	*Solanum nigrum* L.	Leaf	Kaṭu, Tikta	Snigdha	Uṣṇa	Kaṭu
12	Kaṇṭhakārī	*Solanum xanthocarpum* Schrad. & H. Wendl.	Fruit	Tikta, Kaṭu	Laghu, Rūkśa, Uṣṇa	Uṣṇa	–
13	Kāravellaka	*Momordica charantia* L.	Fruit	Tikta	Śīta, Laghu	–	Kaṭu
14	Karkoṭakī	*Momordica dioica* Roxb. ex Willd.	Fruit	Madhura, Tikta	–	Uṣṇa	Kaṭu
15	Kebuka	*Costus speciosus* (J.Koenig) Sm.	Tuber	Tikta, Kaṭu	Laghu	Śīta	Kaṭu
16	Kharbūja	*Cucumis melo* L.	Fruit	Tikta	Laghu, Rūkśa,	–	–
17	Kirātatikta	*Swertia chirata* Buch.-Ham. ex Wall.	Leaf	Tikta	–	–	–
18	Kośātakī	*Luffa acutangula* (L.) Roxb.	Fruit	Tikta	Laghu, Rūkśa, Śīta	–	–
19	Kśīravidārī	*Ipomoea digitata* L.	Tuber	Madhura, Amla, Kaṣāya, Tikta	–	–	–
20	Kūṣmāṇḍa	*Benincasa hispida* (Thunb.) Cogn.	Fruit	Madhura	Laghu, Śīta	Śīta	Madhura
21	Laśuna	*Allium sativum* L.	Tuber (bulb)	Kaṭu, Madhura	Tīkṣṇa, Guru Snigdha, Piccila	Uṣṇa	Kaṭu
22	Loṇī	*Portulaca oleracea* L.	Leaf	Amla, Lavaṇa	Rūkśa, Guru	Uṣṇa	–
23	Maṇḍūka parṇī	*Centella asiatica* (L.) Urb.	Leaf	Madhura, Tikta, Kaṭu,	Laghu, sara	Śīta	Madhura
24	Methikā	*Trigonella foenum-graecum* L.	Seed	Tikta	Snigdha	Uṣṇa	Kaṭu
25	Niṃba	*Azadirachta indica* A. Juss.	Leaves	Tikta, Kaṣāya	Laghu, Rūkśa	Śīta,	Kaṭu
26	Paṭola	*Trichosanthes dioica* Roxb.	Fruit	Tikta, Madhura	Laghu, Snigdha, Uṣṇa	–	Kaṭu
27	Punarnavā	*Boerhaavia diffusa* L.	Leaves	Tikta, Kaṣāya	Laghu, Rūkśa	Uṣṇa	Kaṭu
28	Saptalā	*Acacia concinna* (Willd.)DC.	Leaf	Tikta	–	–	Kaṭu
29	Śitivāra	*Celosia argentea* L.	Leaf	Madhura, Kaṣāya	Rūkśa, Śīta, Laghu	Śīta	Madhura
30	Suniśaṇṇaka	*Marsilea minuta* L.	Leaf	Madhura, Kaṣāya	Rūkśa, Śīta	Śīta	Madhura
31	Suvarcalā	*Malva rotundifolia* L.	Leaf	Madhura	Guru, Rūkśa	Śīta	–
32	Vārāhi	*Dioscorea bulbifera* L.	Tuber	Kaṭu, Tikta, Madhura	–	–	Kaṭu
33	Vāsa	*Adhatoda vasica* Nees	Leaf	Tikta, Kaṭu	Laghu	Śīta	Kaṭu
34	Veṇu karīra	*Bambusa bambos* (L.) Voss.	Tender Stem	Madhura	Rūkśa	–	Madhura
35	Vṛntāka	*Solanum melongena* L.	Fruit	Madhura	Tīkṣṇa, Uṣṇa, Laghu	–	Kaṭu

nutrients, such as foliate, potassium, and carotenoids, and other phytochemicals that may directly reduce cardiovascular disease risk; certain nutrients may directly improve established, diet-related cardiovascular disease risk factors, such as blood pressure, hyperlipidemia, and diabetes.[86] Several studies have highlighted the

Table 2: Classical vegetables reported for their anti-diabetic activity

S. no.	Sanskrit name	Botanical name	Experimental study/clinical study
1	Cakramarda	*Cassia tora* L.	Reduction in blood glucose and lipid levels was observed with doses of 50, 100, and 250 mg/kg, methanolic extract in alloxan-induced diabetogenic rats.[33]
2	Droṇapuṣpī	*Leucas cephalotes* (Roth) Spreng.	The ethanolic extract of leaves at doses of 150, 300, and 450 mg/ kg, showed anti-diabetic activity.[34]
3	Guḍucī	*Tinospora cordifolia* (Willd.) Miers	A significant hypoglycemic effect was observed with the aqueous, alcoholic, and chloroform extracts of the leaves at doses of 50, 100, 150, and 200 mg/kg.[35] Significant anti-diabetic activity was also found with ethanolic extracts at doses of 200 and 400 mg/kg.[36]
4	Kākamācī	*Solanum nigrum* L.	The aqueous and hydro-alcoholic extracts of leaf, fruit, and stem exhibited hypoglycemic activity at a dose of 200 and 400 mg/kg. Significant hypoglycemic activity was observed with aqueous extracts of leaf and fruit followed by hydroalcoholic extracts.[37]
5	Kaṇṭhakārī	*Solanum xanthocarpum* Schrad. & H. Wendl.	An *in vitro* study on glucose utilization by isolated rat hemi diaphragm suggests that the aqueous extract of fruits may have direct insulin like activity, which enhances the peripheral utilization of glucose and has an extra pancreatic effect.[38]
6	Kāravellaka	*Momordica charantia* L.	In alloxan-induced diabetic rats, significant reduction in fasting blood glucose and lipid profile, renal profile, and hepatic profile was observed with a hydro-alcoholic extract of fruit at a dose of 300 mg/kg.[39] Fruit administered for 30 days at doses of 150 and 300 mg/kg exhibited significant anti-hyperglycemic activity.[40] Suppression of gluconeogenesis was observed in normal and streptozotocin (STZ)-induced diabetic rats after the administration of ethanol extract at a dose of 200 mg/kg.[41] Significant reduction in blood glucose and serum insulin level was observed with a water extract of the fruit.[42]
7	Karkoṭakī	*Momordica dioica* Roxb.	Reduction in serum glucose level and increase in serum insulin level was found in streptozotocin-diabetic rats after administration of *M. dioica* extract at a dose of 300 mg/kg Protective effect on the kidney in severe diabetes was also evident from the histological examinations.[43] Significant anti-diabetic activity in alloxan-induced diabetic rats was observed with ethyl acetate and alcohol extracts at a dose of 200 mg/kg.[44]
8	Kebuka	*Costus speciosus* (J.Koenig) Sm.	Significant reduction in blood glucose and glycosylated hemoglobin was observed after the administration of an ethanol extract of *C. speciosus* rhizome at a dose of 200 mg/kg.[45] Nanoparticles of *C. speciosus* at doses of 50, 100, and 150 mg/kg significantly decreased the blood glucose, serum total cholesterol, triglyceride, LDL cholesterol, alterations in the expression of insulin (I&II), gluconeogenic genes, and DNA fragmentation.[46]
9	Kirātatikta	*Swertia chirata* Buch.-Ham. ex Wall.	*S. chirata* methanolic extract at a dose of 50 mg/kg is reported for significant anti-diabetic activity.[47] Significant anti-diabetic activity was observed with the ethanolic extract at a dose of 250 mg/kg and 500 mg/kg.[48]
10	Kośātakī	*Luffa acutangula* (L.) Roxb.	Different extracts of *L. acutangula* at doses of 100, 200, and 400 mg/kg were studied in the management of diabetes and related complications in diabetic rats. The methanol extract at a dose of 100 mg/kg was found to be active, but the anti-diabetic activity was increased significantly at doses of 200 and 400 mg/kg as compared to the aqueous extract.[49]
11	Kśīravidārī	*Ipomoea digitata* L.	In an experimental study, significant reduction in the blood glucose level was observed after the administration of 100 and 200 mg/kg hydro-alcoholic extract of tuber. Significant reduction in blood glucose levels was also found in the chronic study.[50] Significant anti-diabetic activity was observed with alcohol and water extracts at doses of 100, 200, and 400 mg/kg.[51]
12	Laśuna	*Allium sativum* L.	Daily treatment of STZ-induced diabetic rats with an extract of raw garlic (500 mg/kg intraperitoneally) for seven weeks showed 57% less serum glucose, 40% lower serum cholesterol levels, and 35% lower triglyceride compared to control diabetic rats.[52] The garlic extract at doses of 0.1, 0.25, and 0.5 mg/kg significantly decreased serum glucose, total cholesterol, triglycerides, and urea, while it increased serum insulin in STZ-induced diabetic rats.[53]
13	Loṇī	*Portulaca oleracea* L.	The significant reduction of serum glucose levels was observed at a dose of 400 mg/kg b.w.[54] The extract of *P. oleracea* leaves at doses of 100 mg/kg and 250 mg/kg for three weeks showed a significant reduction in thiobarbituric acid reactive substances (TBRAS) and an increase in glutathione reductase (GSH-R) in both the liver and kidneys of STZ–induced diabetic rats.[55]
14	Maṇḍūkaparṇī	*Centella asiatica* (L.) Urb.	The ethanolic and methanolic extracts of the leaves at a dose of 250 mg/kg has shown significant anti-diabetic activity.[56] In another experimental study, powder at doses of 50, 100, and 200 mg/kg significantly lowered the blood glucose levels.[57]

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S. no.	*Sanskrit name*	*Botanical name*	*Experimental study/clinical study*
15	Paṭola	*Trichosanthes dioica* Roxb.	The aqueous extract of *T. dioica* fruits at a dose of 1,000 mg/kg body weight reduced the levels of fasting blood glucose, postprandial glucose, and urine sugar.[58] The aqueous fruit extract exhibited maximum fall in the blood glucose level of 23.8% in normal rats and of 31.3% in mild diabetic rats at a dose of 1,000 mg/kg. In severely diabetic rats, fasting blood glucose and postprandial glucose levels were reduced by 28.7 and 30.7%, respectively.[59]
16	Varāhikaṅda	*Dioscorea bulbifera* L.	The ethanolic extract of *D. bulbifera* tuber at doses of 380, 760, and 1,140 mg/kg body weight exhibited a significant reduction in the blood glucose levels of the albino rats.[60] The aqueous extract at 250, 500, and 1,000 mg/kg doses administered for 3 weeks to STZ treated rats showed significant anti-hyperglycemic effects.[61]
17	Vāsā	*Adhatoda vasica* Nees	*A. vasica* ethanolic extract and fractions showed dose dependent *in vitro* anti-diabetic activity.[62] The ethanolic extracts of leaves at 50 and 100 mg/kg produced a significant reduction in blood glucose levels in normal and experimental diabetic rats.[63]

Table 3: Classical vegetables reported for their anti-hyperlipidemic activity

S. no.	*Sanskrit name*	*Botanical name*	*Experimental/clinical study*
1	Alābu	*Lagenaria siceraria* (Molina) Standl.	Oral administration of petroleum ether, chloroform, alcoholic and aqueous extracts, at doses of 200 and 400 mg/kg body weight in rats, dose-dependent inhibition of the total cholesterol, triglycerides, low-density lipoprotein level, and significant increase of the high-density lipoprotein level.[68]
2	Kāravellaka	*Momordica charantia* L.	Hypolipidemic activity in old obese rats was evaluated by treating two groups with *M. charantia* fruit extract (150 & 300 mg/kg). A significant reduction in the serum cholesterol and glyceride levels of obese rats following the treatment was observed.[69]
3	Kebuka	*Costus speciosus* (J.Koenig) Sm.	The root extract at doses of 300 and 450 mg/kg reversed the hyperlipidemia by reducing the plasma total lipid, cholesterol, triglyceride, and improved hepatic antioxidant and enzyme activities in experimental animals.[70]
4	Kharbūja	*Cucumis melo* L.	In high-cholesterol diet-induced hyperlipidemic rats, treatment with *C. melo* fruit peel methanolic and aqueous extract showed significant reduction in body weight, serum lipid profile like total cholesterol, triglyceride, low-density lipoprotein cholesterol level, atherogenic index, and increased the serum high-density lipoprotein cholesterol levels compared to the hyperlipidemic control group.[71]
5	Kirātatikta	*Swertia chirata* Buch.-Ham. ex Wall.	The ethanol extract of *S. chirata* at a dose of 400 mg/kg showed significant anti-hyperlipidemic activity in cholesterol suspension-induced hypercholesterolemia rats.[72]
6	Koshataki	*Luffa acutangula* (L.) Roxb.	Methanol and aqueous extracts of *L. acutangula* fruit at doses of 100, 200, and 400 mg/kg were screened for antioxidant, anti-diabetic, and anti-hyperlipidemic potential. The methanolic extract showed dose dependent pronounced anti-hyperlipidemic activity over the aqueous extract.[73]
7	Kūṣmāṇḍa	*Benincasa hispida* (Thunb.) Cogn.	Salad was prepared by using 100 g of *B. hispida* and one gm of curry leaves. This salad was freshly prepared every day and given to hyperlipidemic diabetic patients at mid-morning for a period of three months. Supplementation of ash gourd and curry leaves had significant hypoglycemic and hypolipidemic effects and it reduced the blood glucose level within a period of three months.[74]
8	Laśuna	*Allium sativum* L.	Lipid soluble organo-sulphur compounds from garlic were treated *in vitro* with Luke's cysteine reagent (representing the thiol (–SH) group of enzymes) and the interaction products were separated by paper chromatography. The result indicated that organo-sulphur compounds were capable of interacting with the thiol (–SH) group of cysteine, thus forming cysteine derivatives.[75] A meta-analysis of published clinical studies also showed that garlic can reduce the level of TC and LDL instead of HDL and TG, indicating the ability of anti-hyperlipidemia.[76]
9	Maṇḍūkaparṇī	*Centella asiatica* (L.) Urb.	*In vivo* studies showed that *C. asiatica* leaf extracts have excellent antioxidant and anti-hyperlipidemic properties, which might be useful for the treatment of oxidative-stress related diseases such as hyperlipidemia.[77] *In vitro* study revealed that pancreatic lipase inhibitory activity of *C. asiatica* extract was significantly higher than that of rutin but lower than that of orlistat, an anti-obesity drug. *C. asiatica* extract (1,000 and 2,000 mg/4 mL/kg) significantly decreased plasma glucose, TG and TC levels in lipid emulsion-induced hyperlipidemic rats.[78]
10	Methikā	*Trigonella foenum-graecum* L	Powder, aqueous extract, methanolic extract, and oil groups produced a significant decrease in the levels of various serum lipids like TC, TG, LDL, VLDL, and increased HDL.[79]

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S. no.	Sanskrit name	Botanical name	Experimental/clinical study
11	Paṭola	*Trichosanthes dioica* Roxb.	The crude methanolic extract and ethyl acetate fraction significantly reduced the elevated levels of TC, serum triglyceride, LDL cholesterol, and VLDL cholesterol and elevated the decreased level of HDL cholesterol.[80] Cholesterol-lowering activity of the aqueous fruit extract of *T. dioica* is reported in normal and STZ-induced diabetic rats.[81] Oral administration of 2 mL suspension of alcoholic extract of whole fruit lowered the blood sugar, TC, LDL cholesterol, and triglyceride levels and increased HDL cholesterol, phospholipid, and fecal sterol levels in albino rats.[82]
12	Punarnavā	*Boerhaavia diffusa* L.	The extracts of *B diffusa* at doses of 100 and 200 mg/kg body weight were evaluated in high-fat diet-induced hyper lipidaemia. Drug at a dose of 200 mg/kg showed a decrease in the mean TC, TG, LDL, and increase in HDL.[83]
13	Vṛntāka	*Solanum melongena* L.	In a clinical trial, *S. melongena* was administered to hypercholesterolemic human volunteers for 5 weeks. It was observed that *S. melongena* significantly reduced the blood levels of total and LDL cholesterol and apolipoprotein B.[84] In an experimental study, flavonoids extracted from the fruits of *S. melongena*, administered orally at a dose of 1 mg/100 g body weight/day in normal and cholesterol-fed rats showed significant hypolipidaemic action.[85]

cardiovascular disease risk-reducing potential of fruits and vegetables whereby their intake was strongly associated with lower cardiovascular risk factors such as lower blood pressure, cholesterol, and triacylglycerol.[87] Among 33 classical vegetables, indicated as pathya in hṛdroga, 15 vegetables have been reported for their cardio protective activity (Table 4).

Vegetables in Hypertension

According to World Heart Federation, hypertension is a risk factor for coronary heart diseases and the single most important risk factor for stroke. It causes about 50% of ischemic strokes and increases the risk of hemorrhagic stroke.[107] Among the 33 classical vegetables indicated for hṛdroga (cardiovascular disease), seven are reported for their anti-hypertensive activity (Table 5).

Vegetables Reported for Antiplatelet Activity

Platelets play an important role both in normal hemostasis and in pathological thrombus formation. Antiplatelet therapy was considered a key pharmacological method in prevention and treatment of cardiovascular diseases.[117] The antiplatelet activities of five vegetables are reported in different experimental studies (Table 6).

Probable Mechanism of Action

In classical texts of Āyurveda, therapeutic as well as nutritional values of all the vegetables are explained on the basis of predominant pañcabhoutic combination. Analysis of the results showed that majority of the plants indicated in metabolic disorders have tikta rasa, laghu and rūkśa guṇa. All the disorders mentioned under metabolic syndromes are considered as santarpaṇottha vikāra (diseases due to over nutrition) mainly due to the vitiation of kleda predominant doṣa and dūṣya. Therefore, for the management of metabolic disorders, one should select the drugs/diets that act against meda and kleda.

Many metabolites present in vegetables may be responsible for their preventive effect on the development of metabolic disorders. The dietary fiber, potassium, folate, antioxidant content, and low glycemic index of vegetables are helpful in weight management and prevention of the risk of metabolic syndromes. Other different components like minerals and phytochemicals may also play an important role.[123] It is reported that dyslipidemia, hypertension, abnormalities in blood clotting factors, and atherosclerosis also may be due to the higher levels of insulin.[124] Dietary fibers delay the absorption of carbohydrates after a meal and thereby decrease the insulinemic response to dietary carbohydrates.[125] They also increase the satiety, reduce hunger, decrease the energy intake, contribute to weight control, and prevent obesity.[126] Water soluble dietary fiber has been shown to decrease both TC and LDL, without affecting HDL.[127] In a multi-centric study of 2,909 healthy young adults aged between 15 and 30 years, dietary fiber intake was inversely associated with body weight, waist to hip ratio and fasting insulin levels.[128] Dietary fiber supplementation is reported to reduce the blood pressure by significant levels.[129] Another important functional aspect of vegetables is their low glycemic index and glycemic load.[130] Evidence suggests that the replacement of high glycemic index foods in the diet by fruits and vegetables may have a wide range of benefits including reduced risks of obesity, coronary heart disease, and development of type 2 diabetes. A diet with a low glycemic index is associated with lower risks of type 2 diabetes and coronary heart diseases.[131,132] Folic acid may be an important constituent for the protective effect against metabolic syndrome. Folic acid and vitamin B 12 are important for the metabolism of homocysteine.

Table 4: Classical vegetables reported for their cardio protective activity

S. no.	*Sanskrit name*	*Botanical name*	*Experimental/clinical study*
1	Alābu	*Lagenaria siceraria* (Molina) Standl.	Pretreatment of the fruit powder (500 mg/kg) for 51 days showed protective activity isoprenaline-induced cardio toxicity.[88] Fruit juice (400 mg/kg/day, p.o.) for 30 days showed a protective effect on altered biochemical and histopathological changes in isoproterenol-induced myocardial infarction.[89]
2	Cakramarda	*Cassia tora* L.	Early treatment with the extract (100 mg/kg, 200 mg/kg) showed a significant decrease in the level of serum marker enzymes in isoproterenol-induced myocardial injury.[90]
3	Gṛñjana	*Daucus carota* L.	The aqueous extract of tubers at test doses of 250 and 500 mg/kg exhibited a cardio protective effect on isoproterenol-induced myocardial infractions in rats.[91]
4	Guḍucī	*Tinospora cordifolia* (Willd.) Miers	The alcoholic extract of whole plant showed a dose dependent reduction in infarct size and in lipid peroxide levels of serum and heart tissues.[92]
5	Kākamacī	*Solanum nigrum* L.	The methanolic extract (2.5 and 5.0 mg/kg) exhibited cardio protective activity against *in vitro* ischemia-reperfusion injury.[93]
6	Kāravellaka	*Momordica charantia* L.	The methanolic extract of fruit reduced the abnormal deposition of glycogen in the left ventricle of STZ- induced diabetic rats.[94]
7	Karkoṭakī	*Momordica dioica* Roxb.	The crude methanolic extract of fruit has reversed the toxicity produced by doxorubicin evidenced by changes in ECG as well as histopathological examination.[95]
8	Kośātakī	*Luffa acutangula* (L.) Roxb.	Pretreatment with the hydro-alcoholic extract at doses of 100, 200, and 400 mg/kg reversed the elevated serum biomarkers, alanine amino transferase, lactate dehydrogenase, and creatinine phosphokinase in the heart of doxorubicin-induced cardiotoxic mice.[96]
9	Kūśmāṇḍa	*Benincasa hispida* (Thunb.) Cogn.	*B. hispida* pulp, core, seed, and peel prepared by different extraction methods showed higher antioxidant capacity and angiotensin-converting enzyme ACE inhibition (ACE) activity.[97]
10	Laśuna	*Allium sativum* L.	Garlic oil exhibited a significant cardio protective activity at a dose of 70 mg/kg by lowering the levels of serum marker enzymes, lipid peroxidation, and elevated levels of GSH in isoproterenol (20 mg/kg)-induced cardiac necrosis.[98]
11	Maṇḍūkaparṇī	*Centella asiatica* (L.) Urb.	Pre-treatment with *C. asiatica* (200 mg/kg) extract significantly prevented myocardial damage in Adriamycin-induced cardiomyopathy.[99] The alcoholic extract of the whole plant showed strong cardio protective activity in ischemia-reperfusion induced myocardial infraction in rats.[100]
12	Methikā	*Trigonella foenum-graecum* L.	Pre-treatment with the ethanolic extract of the whole plant at doses of 200 and 400 mg/kg strongly protected the myocardium against isoproterenol-induced infarction.[101]
13	Niṃba	*Azadirachta indica* A. Juss.	The aqueous leaf extracts at doses of 250, 500, and 1,000 mg/kg showed a significant effect on haemodynamic, biochemical, and histopathological parameters in the experimental model of isoprenaline- induced myocardial necrosis in rats.[102]
14	Punarnavā	*Boerhaavia diffusa* L.	The ethanolic extract revealed protective effects against mitochondrial dysfunction in angiotensin II (Ang II)-induced hypertrophy of H9c2 cardiomyoblast cells.[103]
15	Vṛntāka	*Solanum melongena* L.	Aqueous fraction, ethyl acetate fraction, and chloroform fraction potently inhibited platelet aggregation, antioxidant property, and calcium channel blocking activity, respectively.[104] The *S. melongena* extract produced dose-dependent hypotensive responses in normotensive albino rats.[105] Raw and grilled eggplants increased the left ventricular function, and reduced myocardial infarct size and cardiomyocyte apoptosis.[106]

Elevated homocysteine concentrations have been related to an increased CVD risk.[133] Dietary intake of folate has been shown to be inversely associated with the plasma concentration of homocysteine.[134] Vasculo-protective effect of folate is also reported.[135] Different antioxidants present in the vegetables may act in combination with each other and other phytochemicals within the food to provide beneficial effects. Vegetables are rich sources of antioxidants such as vitamin A, vitamin C, polyphenols, flavonoids, and carotenoids, which may help to prevent atherosclerosis and subsequent ischemic heart diseases. Some studies show that antioxidant may have a protective effect on diabetes.[136]

CONCLUSION

In the present review, the role of different vegetables mentioned in classical texts of Āyurveda in the prevention as well as management of metabolic syndromes is presented in a systematic manner. Though some of these vegetables are wild edible plants, they can also be cultivated according to the season of availability. The reported experimental evidence also supports the role of classical vegetables as a diet in metabolic diseases. Further clinical studies are required to understand how these drugs can be helpful in clinical practice. The effective dosage and toxicity of these plants need to be defined.

Table 5: Classical vegetables reported for their anti-hypertensive activity

S. no.	Sanskrit name	Botanical name	Experimental/clinical study
1	Alābu	*Lagenaria siceraria* (Molina) Standl.	The aqueous extract of *L. siceraria* showed a significant anti-hypertensive effect in dexamethasone-induced hypertension.[108] Fruit powder significantly reduced systolic and diastolic blood pressures in N(G)-nitro-L-arginine methyl ester (L-NAME)-induced hypertensive rats.[109]
2	Kāravellaka	*Momordica charantia* L.	Acute intravenous administration of the whole-plant aqueous extract produced dose-dependent, significant reductions in systemic arterial blood pressure and heart rates of normal and hypertensive rats.[110]
3	Laśuna	*Allium sativum* L.	Single or multiple doses of 0.5 mL of aqueous extract were given orally to hypertensive rats. Single dose showed a maximum anti-hypertensive effect 2–6 hours after administration. Multiple doses of the extract appeared to be effective in restraining the expected rise in blood pressure.[111] Administration of a single dose of garlic (20 and 40 mg/kg), produced significant reduction in diastolic blood pressure and mean arterial pressure in Wistar rats.[112]
4	Maṇḍūkaparṇī	*Centella asiatica* (L.) Urb.	The extract (4, 8, 16, or 32 g/20 mL/kg) significantly lowered the elevated mean arterial blood pressure, systolic blood pressure, and diastolic blood pressure of (L-NAME)-induced hypertensive rats.[113]
5	Methikā	*Trigonella foenum-graecum* L.	Chronic administration of the methanol extract (30 mg/kg/day) and methanol fraction (15 mg/kg/day) significantly reduced the blood pressure in deoxycorticosterone acetate (DOCA)-salt-induced and fructose-induced hypertensive rats.[114]
6	Niṃba	*Azadirachta indica* A. Juss.	Pestalotiopsis species were the most dominant endophytic species isolated from four medicinal plants including A. indica. The obtained antioxidant, antibacterial, and antihypertensive activities of these extracts demonstrated the potential of Pestalotiopsis extracts as therapeutic targets.[115]
7	Paṭola	*Trichosanthes dioica* Roxb.	Aqueous, ethanol, petroleum ether, and chloroform extracts of were given orally in dexamethasone induced hypertensive rats. The aqueous extract showed a potent anti-hypertensive effect.[116]

Table 6: Classical vegetables reported for their antiplatelet activities

S. no.	Sanskrit name	Botanical name	Experimental/clinical study
1	Laśuna	*Allium sativum* L.	*In vitro* anti-platelet activity was examined on human platelet aggregation by light transmission aggregometry after induction by adenosine diphosphate, collagen, epinephrine, and arachidonic acid in platelets from healthy volunteers. The extract showed anti-aggregatory effects by the inhibition of the ADP pathway.[118]
2	Maṇḍūkaparṇī	*Centella asiatica* (L.) Urb.	*In vitro* effects of a methanol extract from the aerial parts were assessed on shear-induced platelet activation and coagulation. Amongst different isolated constituents, 3,5-di-O-caffeoylquinic acid showed significant inhibition of shear-induced platelet activation and dynamic coagulation.[119]
3	Alābu	*Lagenaria siceraria* (Molina) Standl.	The ethanolic extract of the fruits showed a significant increase in the tail bleeding time and plasma recalcification time, significant protection against ADP induced pulmonary thromboembolism in mice, and also inhibited platelet aggregation induced by ADP *in vitro*.[120]
4	Vṛntāka	*Solanum melongena* L.	Anti-platelet activity was monitored using a dual channel Lumi aggregometer and calcium channel blocking activity on guinea pig ileum using an isolated organ bath assembly. The aqueous, ethyl acetate, and chloroform fraction potently inhibited platelet aggregation and showed calcium channel blocking activity.[121]
5	Methikā	*Trigonella foenum-graecum* L.	The effect of *T foenum-graecum* extract was evaluated to determine the response of rabbit platelets to ADP-induced aggregation. The extract (0.5, 1, 1.5, and 3 mg/mL) inhibited ADP-induced platelet aggregation.[122]

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हिन्दी सारांश

चयापचय विकारों में पथ्य के रूप में शाकद्रव्य (सब्जियों) का उपयोग – आयुर्वेदीय ग्रंथों में उपलब्ध वर्णन की वर्तमान साक्ष्यों के साथ समीक्षा

उद्देश्य: प्रमेह/मधुमेह, हृदयरोग, स्थौल्य जैसे चयापचय व्याधियों में उल्लिखित शाकद्रव्यों की 15 विभिन्न शास्त्रीय आयुर्वेद ग्रंथों से समीक्षा करना तथा संबंधित विभिन्न अनुसंधान कार्यों के सहयोग से उपलब्ध जानकारी का विश्लेषण करना ताकि चयापचय विकारों के निवारण एवं प्रबंधन में उनकी भूमिका को सिद्ध किया जा सके |

पृष्ठभूमि: चयापचय विकार एक बहुघटकीय व्याधि है, जिसे जीवनशैली के परिवर्तन और आहार की आदतों द्वारा रोका जा सकता है | आयुर्वेद ग्रंथों में आहार को श्रेष्ठ माना गया है और आयुर्वेद के शास्त्रीय ग्रंथों में उपलब्ध विभिन्न व्याधि निवारण उपायों में सभी शाकद्रव्यों का वर्णन उनके गुण, कर्म और प्रयोग के साथ शाकवर्ग के अंतर्गत किया गया है | चूँकि आहार को श्रेष्ठ उपचारात्मक औषधि माना गया है, अतः प्रमेह/मधुमेह, हृदयरोग, स्थौल्य जैसे चयापचय विकारों के निवारण के लिए शाकद्रव्यों को पथ्य (सम्पूर्ण आहार) के रूप में इंगित किया गया है |

समीक्षा परिणाम: यह देखा गया है कि आयुर्वेदीय शास्त्रीय ग्रंथों में उल्लिखित 318 सब्जियों में से 29 को प्रमेह/मधुमेह और 33 को हृदय रोग में पथ्य के रूप में इंगित किया गया है | अनुसंधान कार्यों से भी यह सिद्ध हुआ है कि अधिकांश शाकद्रव्यों में एंटी डायबिटिक(18), एंटी हाइपरलिपीडेमिया (14), कार्डियोप्रोटेक्टिव (15), एंटी हाइपरटेंसिव (7) और एंटी प्लेटलेट (7) का प्रभाव परिलक्षित है |

निष्कर्ष: प्रस्तुत अवलोकन में आयुर्वेद में वर्णित शाकद्रव्यों का पथ्य के रूप में उपयोग चयापचय व्याधियों में प्रभावशाली रूप से किया जा सकता है |

नैदानिक महत्व: समीक्षा परिणामों के आधार पर चयापचय व्याधियों में शाकद्रव्यों के उपयोग के लाभकारी प्रभाव का वैज्ञानिक अध्ययन किया जा सकता है |

मुख्य शब्द: चयापचय विकार , पौष्टिक औषधीय पदार्थ, पथ्य, शाकवर्ग