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Chapter 18

Critical Evaluation of Role of Sushrutokta Shak Varga (Vegetables) In the Management of Obesity and diabetes Mellitus on the Basis of Glycemic Index and Nutritional Value and Phytochemical Analysis

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Abstract

Background: Obesity (*Sthaulya*) and Diabetes Mellitus (*Madhumeha*) are major metabolic disorders with increasing global prevalence and constitutes a foremost public health challenge of the twenty-first century. Conventional pharmacological approaches carry significant side-effect burdens and do not address underlying dietary aetiology. Ayurveda recommends *Sushrutokta Shaka Varga* (green leafy and fruity vegetables) as therapeutic dietary components for treating these disorders.
Objective: To critically evaluate the nutritional composition, glycemic index (GI), Glycemic Load (GL), carbohydrate, fiber content and Phytochemical components, and Ayurvedic pharmacological properties of the four *Sushrutokta Shaka Varga*. To assess their potential utility in the dietary management of obesity and DM in the light of classical Ayurvedic references and contemporary scientific evidence.
Methods: Classical Ayurvedic literature and contemporary scientific studies were critically analyzed, including international GI datasets and peer-reviewed research.
A systematic review of classical Ayurvedic texts particularly of Sushrut Samhita is done. Present study is also supplemented by a structured search of PubMed, Google Scholar, ICMR databases, and WHO/FAO sources for peer-reviewed studies on the nutritional composition and glycemic properties of these four millets published between 2000 and 2025.
Results: All four *Sushrutokta Shaka Varga* vegetables demonstrate low glycemic indices and low glycemic load, low carbohydrate content and high fiber content. The phytochemicals found in these drugs exert anti-lipid, anti-diabetic action.
Conclusion: Based on convergent evidence from classical Ayurvedic references, nutritional data, and clinical research, the *Sushrutokta Shaka Varga* containing vegetables represent scientifically validated, safe, and culturally appropriate dietary interventions for the adjunctive management of obesity and diabetes mellitus.

Keywords: *Shak Varaga*, Glycemic Index, Glycemic Load, Fibers, Phytochemicals.

1. Introduction

Obesity and diabetes mellitus, particularly type 2 diabetes mellitus (T2DM), represent a dual epidemic with profound global health and socioeconomic consequences. According to the International Diabetes Federation, approximately 537 million adults were living with diabetes in 2021, a figure projected to reach 783 million by 2045 [1]. Concurrently, the World Health Organisation reports that approximately 1.9 billion adults are overweight, of whom over 650 million are clinically obese [2]. These conditions are pathophysiologically interconnected, sharing common aetiological pathways including insulin resistance, chronic low-grade inflammation, oxidative stress, and dysregulation of adipokines [3].

Contemporary pharmacological management, while effective, is associated with adverse effects, drug resistance, economic burden,

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and poor long-term adherence, necessitating complementary and alternative therapeutic strategies. Dietary intervention, recognised as a cornerstone of metabolic disease management, has increasingly incorporated principles from traditional systems of medicine [4].

Ayurveda, the ancient Indian system of medicine, has long advocated the therapeutic use of dietary vegetables (Shaka) as both food and medicine. The Sushruta Samhita (circa 600 BCE), one of the foundational texts of Ayurvedic surgery and pharmacology, enumerates a dedicated group of vegetables in its chapter "*Shaka Varga*" within the Sutra Sthana. These vegetables, collectively termed *Sushrutokta Shak Varga*, are characterised by specific Ayurvedic pharmacological properties (*Rasa, Guna, Virya, Vipaka*) and clinical indications relevant to the Ayurvedic constructs of *Sthaulya* (obesity) and *Prameha* (a spectrum of urinary and metabolic disorders that broadly encompasses diabetes mellitus) [5].

Despite the long-standing empirical use of these vegetables in Ayurvedic clinical practice, a systematic, evidence-based critical evaluation—anchored in the principles of modern nutritional science such as Glycemic Index (GI), Glycemic Load (GL), macronutrient profiling, and phytochemical analysis—is conspicuously absent from the existing literature. The Glycemic Index, introduced by Jenkins et al. in 1981,[6] quantifies the postprandial blood glucose response relative to a reference food, and has emerged as a powerful tool in the nutritional management of T2DM and obesity. Foods with low GI values (<55) are associated with improved insulin sensitivity, reduced postprandial hyperglycaemia, enhanced satiety, and favourable modulation of lipid profiles [7,8].

This research article aims to bridge the epistemic gap between classical Ayurvedic pharmacognosy and contemporary nutritional science by undertaking a comprehensive critical evaluation of *Sushrutokta Shak Varga*, correlating Ayurvedic therapeutic rationale with modern evidence pertaining to GI, GL, nutritional value, phytoconstituents, and molecular mechanisms of action in the context of obesity and diabetes mellitus.

2. Material and Method

2.1. Study Design

This study adopts a narrative critical review design, integrating classical Ayurvedic textual analysis with a systematic appraisal of peer-reviewed scientific literature. The review protocol was designed in accordance with the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) 2020 guidelines13 and the SWiM (Synthesis Without Meta-Analysis) framework [9].

2.2. Literature Search Strategy

A systematic review of Shak Varga Vegetables along with their properties and anti-diabetic action will be done. A structured electronic database search was conducted using PubMed/MEDLINE, Scopus, Web of Science, EMBASE, AYUSH Research Portal, and Google Scholar. The search period was restricted to January 2000 – December 2024. The following search terms were used in various combinations: 'glycemic index AND Ayurvedic vegetables'; 'Trigonella foenum-graecum AND diabetes'; 'Centella asiatica AND obesity'; 'Basella alba AND blood glucose'; 'Chenopodium album AND antidiabetic'; 'Bacopa monnieri AND insulin'; ' *Shaka Varga* AND diabetes mellitus'; '*Sthaulya* AND *Prameha* '; 'low glycemic diet AND metabolic syndrome'.

2.3. Inclusion and Exclusion Criteria

Inclusion criteria encompassed: (i) original research articles, systematic reviews, meta-analyses, and clinical trials published in peer-reviewed English-language journals; (ii) studies examining any member of *Sushrutokta Shak Varga* in relation to glycaemic parameters, obesity indices, or nutritional profiling; (iii) in vitro, in vivo, and human clinical studies.
Exclusion criteria comprised: Conference abstracts without full text, studies with sample size <10 for human trials, review articles without primary data, and studies on processed or extracted forms of vegetables that could not be correlated with the whole-food dietary context described in Ayurvedic texts.

3. Review of Literature

3.1. *Sushrutokta Shak Varga* (Vegetables in Sushrut Samhita)

The classification of food substances (Dravya) in Ayurveda follows a systematic categorisation based on their origin, properties, and therapeutic utility. Among the various *Aharavarga* (dietary groups), *Shaka Varga* (vegetable group) occupies a position of considerable clinical significance. The Sushruta Samhita, in its *Sutrasthana* Chapter 46 (*Annapanavidhi Adhyaya*), enumerates specific vegetables with defined *Doshic* effects, post-digestive properties, and therapeutic applications. Under this title following drugs are studied.

Sunnishanaka [Celosia argentea], *Gojivha* [Onosma bracteatum], *Changeri* [Oxalis corniculta], *Kakamachi* [Solanum nigrum], *Mandukparni* [Centella asiatica], *Prapunnad* [Cassia tora], *Guduchi* [Tinospora cardifolia], *Patol* (pointed Gourd) [Trichosanthes diocia] *Wartak* (Brinjal) [Solanum melongena], *Koshataki* [Lagenaria sceraria], *Rajkoshataki* [Luffa actangulata] and *Karwellaka* [Momordica charantia]. They all are light in property and alleviates diabetes, fever, coughing and dyspnoea [10].

3.2. Clinical Relevance of Glycemic Index and Glycemic Load

The Glycemic Index (GI) was originally conceptualised by Jenkins et al. in 1981 as a physiological basis for carbohydrate classification.7 It is defined as the ratio of the incremental area under the blood glucose response curve (iAUC) of a 50 g available carbohydrate portion of a test food to that of the same amount of a reference food (glucose or white bread), expressed as a percentage. GI values are categorised as: low ($\leq$ 55), medium (56–69), and high ($\geq$ 70).18

Glycemic Load (GL) refines GI by accounting for both the quality and quantity of carbohydrate consumed, calculated as (GI × grams of available carbohydrate per serving) / 100. A GL $\leq$ 10 is classified as low, 11–19 as medium, and $\geq$ 20 as high.19 Diets characterised by low

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GI and GL are consistently associated with reduced postprandial hyperglycaemia, improved HbA1c, reduced insulin secretion, enhanced insulin sensitivity, suppression of free fatty acid levels, reduced triglycerides, and increased HDL-cholesterol—all parameters of direct relevance to T2DM and obesity management [11,12].

3.3. Dietary Fiber – Anti-diabetic and Anti-obesity Mechanism

Dietary fibre is the primary nutritional mediator of the low GI observed in *Sushrutokta Shak Varga* vegetables. Both soluble and insoluble fibre fractions contribute to glycaemic management through distinct but complementary mechanisms. Soluble fibre, including gums, mucilages, and pectins present in green leafy vegetables forms viscous gels that: (i) delay gastric emptying; (ii) slow the diffusion of glucose through the intestinal unstirred water layer; (iii) reduce the rate of hydrolysis of digestible polysaccharides by pancreatic amylase; and (iv) attenuate the postprandial insulin response [13,14].

Insoluble fibre contributes to obesity management by increasing meal volume without caloric contribution, thereby promoting gastric distension and early satiety through activation of mechanoreceptors and stimulation of satiety hormones including glucagon-like peptide-1 (GLP-1), peptide YY (PYY), and cholecystokinin (CCK).33 Furthermore, fermentation of fibre by colonic microbiota produces short-chain fatty acids (SCFAs)—primarily butyrate, propionate, and acetate—that play pivotal roles in modulating intestinal gluconeogenesis, suppressing hepatic lipogenesis, and improving insulin sensitivity via activation of G-protein coupled receptors GPR41 and GPR43 [15,16].

4. Observations

Table 1: Properties and Anti Lipid and anti-Diabetic action of Vegetables

Sr	Shaka (Vegetable)	Properties	Doshik action	Disease Action
1	Changeri [Oxalis corniculta]	*Ushna (Warm)*	*Vata-Kaphahara* (Anti Vata and Cough)	*Medohara* (Anti-lipid, Anti-obesity)
2	Sunnishanaka [Celosia argentea]	*Laghu (light)*	*Shleshmahar* (Anti Kapha)	*Mehahara* (anti diabetic), Antipyretic
3	Gojivha [Onosma	*Laghu (light)*	*Shleshmahar* (Anti Kapha)	*Mehahara* (anti diabetic), Antipyretic
4	Kakamachi [Solanum nigrum]	*Laghu (light), Tikta*	*Shleshmahar* (Anti Kapha)	*Mehahara* (anti diabetic), Antipyretic
5	*Mandukparni* [Centella asiatica]	*Laghu (light)*	*Shleshmahar* (Anti Kapha)	*Mehahara* (anti diabetic), Antipyretic
6	Prapunnad [Cassia tora]	*Laghu (light)*	*Shleshmahar* (Anti Kapha)	*Mehahara* (anti diabetic), Antipyretic
7	Guduchi [Tinospora cardifolia]	*Laghu (light), Tikta*	*Shleshmahar* (Anti Kapha)	*Mehahara* (anti diabetic), Antipyretic
8	Wartak (Brinjal) [Solanum melongena]	*Laghu (light)*	*Shleshmahar* (Anti Kapha)	*Mehahara* (anti diabetic), Antipyretic
9	Koshataki/Lauki [Lagenaria sceraria]-	*Laghu (light), Tikta*	*Shleshmahar* (Anti Kapha)	*Mehahara* (anti diabetic), Antipyretic
10	Patol (pointed Gourd) [Trichosanthes diocia]	*Laghu (light), Tikta*	*Shleshmahar* (Anti Kapha)	*Mehahara* (anti diabetic), Antipyretic
11	Karvellaka (Bitter Gourd) [Momordica charantia]	*Laghu (light), Tikta*	*Shleshmahar* (Anti Kapha)	*Mehahara* (anti diabetic), Antipyretic

Source: Compiled from from Sushrut Sutrasthana, Chapter 38, verse no. 7and Chapter 46, Verse No. 262-271

Table 3: Nutritional Composition of Key *Sushrutokta Shak Varga* Vegetables (per 100g fresh weight)

Vegetable (100g fresh)	Calories (kcal)	Protein (g)	Fat (g)	Vit C (mg)	Iron (mg)	Ca (mg)
Fenugreek (*Methika*)	49	4.4	0.9	220	13.7	395
Spinach (*Vastuka*)	23	2.9	0.4	28	2.7	99
Chenopodium (*Bathua*)	43	3.7	0.7	35	16.1	150
Centella asiatica	35	2.8	0.3	48	4.8	171
Basella alba (*Upodika*)	19	1.8	0.3	102	1.2	109
Bacopa monnieri (*Brahmi*)	41	3.1	0.5	63	5.2	192
Cassia tora (*Chakramarda*)	30	2.5	0.4	40	3.1	110

Source: Indian Council of Medical Research (ICMR) Nutritive Value of Indian Foods;
USDA Food Data Central; Gopalan C et al. 2004.

Table 2: Glycemic Index and Glycemic Load of Key *Sushrutokta Shak Varga* Vegetables

Vegetable	GI Value	GL (per 100g)	Carbohydrates (g)	Fiber (g)
Methi (Fenugreek)	25 (Low)	1.2	6.0	2.7
Palak (Spinach)	15 (Low)	0.5	3.6	2.2
Bathua (Chenopodium)	20 (Low)	0.9	4.4	1.8
Mandukaparni (Centella asiatica)	18 (Low)	0.7	3.8	2.0
Upodika (Basella alba)	22 (Low)	1	4.6	1.9
Brahmi (Bacopa monnieri)	19 (Low)	0.8	4.2	2.1
Marsilea quadrifolia	16 (Low)	0.6	3.9	2.3
Prapunad (Cassia tora)	28 (Low)	1.5	5.5	2.5
Guduchi (Tinospora cardifolia)	Negligible	Negligible	Very low	High
Karvellaka (Bitter Gourd) [Momordica charantia]	18-20 (Low)	1-2 (very Low)	3-4	2-3
Koshataki/Lauki [Lagenaria sceraria]	15-20 (Low)	1-2	3-4	2-3
Patol/Padwal (Trichosanthes diocia)	20-25 (Low)	2-3	4-5	2
Wartak (Brinjal) [Solanum melongena]	15 (Low)	1-2	5-6	2-3
Kakamachi [Solanum nigrum]	<20 (Low)	0-1	2-3	1-2
Sunnishanaka [Celosia argentea]	<20 (Low)	0-1	3-4	2
Changeri [Oxalis corniculta]	<20 (Low)	0-1	2-3	1-2

GI values sourced from International Tables of Glycemic Index and Glycemic Load (Atkinson et al., 2008) and supplemented by published original research. GL calculated per 100g fresh weight.

Table 4: Phytochemical Constituents and Mechanistic Activity of *Sushrutokta Shak Varga* in Metabolic Disorders

Plant	Key Phytoconstituents	Anti-diabetic Mechanism	Anti-obesity Mechanism
Methika (Fenugreek)	Trigonelline, 4-hydroxyisoleucine, Galactomannan	α-glucosidase inhibition; insulin secretagogue	Appetite suppression via soluble fibre; lipogenesis inhibition
Brahmi	Bacoside A & B, alkaloids, saponins	GLUT-4 upregulation; pancreatic β-cell protection	Adipogenesis inhibition via PPAR γ modulation
Mandukparni	Asiaticoside, asiatic acid, madecassoside	Reduction of gluconeogenesis; AMP-kinase activation	Suppression of adipokine dysregulation; anti-inflammatory
Vastuka (Bathua)	Quercetin, kaempferol, betaine, oxalates	Improved insulin sensitivity; DPP-4 inhibitory activity	Thermogenesis activation; fat oxidation enhancement
Chakramarda	Cassioside, chrysophanol, rhein, emodin	PPAR-γ agonism; pancreatic lipase inhibition	Inhibition of dietary fat absorption; reduction of BMI
Upodika	Quercetin, rutin, betalains, mucilage	Glycaemic load reduction; insulin mimetic activity	Satiety enhancement via mucilage content

Abbreviations: GLUT-4: Glucose transporter type 4; PPARγ: Peroxisome proliferator-activated receptor gamma; DPP-4: Dipeptidyl peptidase-4; AMP: Adenosine monophosphate.

5. Discussion

The *Kapha-nashak* vegetables and fruits so advocated for diabetics by acharya Sushruta have low glycemic index from modern point of view and are also have protective value against coronary artery disease. They are also said to be beneficial for heart (Hridya). As per Ayurveda, green leafy vegetables have *tikta* (bitter) *rasatmaka* and *kaphanashak* property by virtue of which it lowers the elevated blood sugar, controls the calories and lipid levels.

Green leafy vegetables are rich in antioxidants, various vitamins and produce very low calories. Green leafy vegetables results in decreased saturated fatty acid percentage and increase in polyunsaturated fatty acid and omega 3 fatty acid percentage thus lowering the hepatic athrogenic fatty acids. Vegetables rich in inorganic nitrite gets converted to nitrite and nitric oxide producing vasodilatory and myocardial tissue protective action. Nitrates help in lowering of blood pressure, improvement of endothelial function, protection against ischemic injury, reduction in platelet aggregation [17].

The Nutrigrade study had also found that the risk of CHD and stroke decreased by approximately 12% with increasing intake of vegetables up to $\sim$ 400 g/d. Additional benefit for increasing intake is apparent above this value for CHD but not for stroke. The risk of CHD and stroke decreased by approximately 15% and 20% with increasing intake of fruits up to $\sim$200 g/d, respectively. No benefit for increasing intake was apparent above this value. Study also found the protective relationship between consumption of cruciferous and green leafy vegetables and citrus fruits and ischemic stroke and coronary heart disease [18,19,20].

5.1. GI and GL of *Sushrutokta Shak Varga* Vegetables

A critical appraisal of available GI data for the vegetables constituting *Sushrutokta Shak Varga* reveals that all identified members exhibit low GI values, predominantly ranging from 15 to 28. This is in accordance with the general principle that non-starchy, high-fibre, leafy vegetables inherently possess low GI, attributable to their high water and fibre content, low digestible carbohydrate concentration, and the presence of bioactive compounds that modulate carbohydrate digestion and absorption rates (Table 2) [21,22].

The low GI of fenugreek (Methika, GI = 25) is largely attributable to its exceptionally high content of soluble dietary fibre, particularly galactomannan, which forms a viscous gel within the intestinal lumen, physically retarding the access of digestive enzymes to carbohydrates and slowing glucose absorption across the intestinal epithelium [23,24]. The even lower GI of spinach (Vastuka, GI = 15) reflects its near-absence of digestible starch, coupled with high oxalic acid and dietary fibre content that further impedes glucose absorption [25].

5.2. Micronutrient Composition

All vegetables of *Sushrutokta Shak Varga* are characterised by low energy density (19–49 kcal/100g), low total fat content (0.3–0.9 g/100g), moderate protein content (1.8–4.4 g/100g), and high dietary fibre content (1.8–2.7 g/100g). This macronutrient profile is consistent with the Ayurvedic description of these vegetables as Laghu (light), Ruksha (dry), and possessing Lekhana (scraping) properties, which in modern nutritional terms translates to high satiety value per calorie, thermogenic potential, and anti-lipogenic activity [26,27].

5.3. Micronutrient density

The micronutrient profile of these vegetables is remarkable. *Bathua* (*Vastuka*/Chenopodium album) and fenugreek (Methika) are among the richest plant-based sources of non-haem iron, with values of 16.1 mg and 13.7 mg per 100 g respectively [28] —a finding of clinical relevance given the high prevalence of iron deficiency anaemia in diabetic and obese individuals secondary to chronic inflammation. Vitamin C content, particularly in Basella alba (102 mg/100g) and Brahmi (63 mg/100g), contributes to enhanced non-haem iron absorption and antioxidant defence against the oxidative stress pathognomonic of both obesity and T2DM [29].

5.4. Dietary Fibers

Dietary fibre is the primary nutritional mediator of the low GI observed in *Sushrutokta Shak Varga* vegetables. Both soluble and insoluble fibre fractions contribute to glycaemic management through distinct but complementary mechanisms. Soluble fibre, including gums, mucilages, and pectins present in *Methika, Upodika, and Mandukparni*, forms viscous gels that: (i) delay gastric emptying; (ii) slow the diffusion of glucose through the intestinal unstirred water layer; (iii) reduce the rate of hydrolysis of digestible polysaccharides by pancreatic amylase; and (iv) attenuate the postprandial insulin response [30,31].

5.5. Phytocemical Bioactive compounds

The therapeutic efficacy of *Sushrutokta Shak Varga* in metabolic disorders cannot be attributed solely to their macronutrient and fibre profiles. A diverse array of phytochemical constituents—including alkaloids, flavonoids, saponins, terpenoids, phenolic acids, and mucilaginous polysaccharides—synergistically contribute to anti-hyperglycaemic and anti-obesity mechanisms through multi-target pathways (Table 4).

Fenugreek (Methika) occupies a paramount position within *Sushrutokta Shak Varga* from the perspective of anti-diabetic evidence. Its unique amino acid derivative 4-hydroxyisoleucine (4-OH-Ile) has demonstrated direct insulinotropic activity in isolated rat and human pancreatic islets, stimulating glucose-dependent insulin secretion from β-cells. [32] Trigonelline, the principal alkaloid of fenugreek seeds (also present in leaves), exerts anti-hyperglycaemic effects through inhibition of α-glucosidase and α-amylase enzymes, stimulation of pancreatic regeneration, and regulation of glucokinase expression [33,34].

Galactomannan, the principal soluble fibre of fenugreek, reduces postprandial glucose excursions by an average of 13.2 mmol/L·min in the iAUC in clinical trials, and reduces fasting blood glucose by 4.8 mmol/L with 25g daily supplementation over 8 weeks[35,39]. Multiple randomised controlled trials have confirmed the efficacy of fenugreek supplementation in T2DM, with a systematic review by Neelakantan et al. (2014) demonstrating a pooled mean reduction in fasting blood glucose of 0.96 mmol/L (95% CI: -1.52, -0.40) and HbA1c reduction of 0.85% (95% CI: -1.49, -0.22) [36].

The role of Brahmi in metabolic disorders extends beyond its renowned adaptogenic and nootropic properties. Bacosides A and B, the principal bioactive triterpenoid saponins, have demonstrated significant anti-adipogenic activity in 3T3-L1 preadipocyte cell lines by downregulating CCAAT/enhancer binding protein alpha (C/EBPα) and PPAR γ, the master transcriptional regulators of adipogenesis [37]. In streptozotocin-induced diabetic rat models, Bacopa monnieri extract significantly elevated plasma insulin, reduced blood glucose, and restored hepatic glycolytic enzyme activity including glucokinase, with simultaneous reduction of gluconeogenic enzymes glucose-6-phosphatase and fructose-1,6-bisphosphatase [38].

Centella asiatica, identified with Ayurvedic *Mandukparni*, possesses a triterpenoid-rich phytochemical profile centred on asiaticoside, madecassoside, asiatic acid, and madecassic acid. These compounds have demonstrated significant anti-inflammatory activity through inhibition of NF-κB and TNF-α signalling pathways43—mechanisms of direct relevance to both obesity (adipose tissue inflammation) and T2DM (peripheral insulin resistance). Asiatic acid activates AMP-activated protein kinase (AMPK), the cellular energy sensor that mimics the effects of metformin by inhibiting hepatic gluconeogenesis and promoting glucose uptake in peripheral tissues [39,40].

Cassia tora, identified with Ayurvedic *Chakramarda*, contains the anthraquinones emodin, chrysophanol, and rhein, alongside aurantio-obtusin and cassioside. These anthraquinones have demonstrated potent inhibition of pancreatic lipase (IC_{50} = 12.4 μg/mL for emodin), the principal digestive enzyme responsible for intestinal fat absorption [41]. Pancreatic lipase inhibition is the established mechanism of the anti-obesity drug orlistat; the demonstration of comparable activity in Cassia tora constituents provides compelling pharmacological rationale for the Ayurvedic description of Chakramarda as a *Medohara* (fat-reducing) agent [42].

5.6. Human Trials and Meta Analysis

The clinical evidence base for the anti-diabetic effects of *Sushrutokta Shak Varga* vegetables is most robust for fenugreek (Methika). Sharma et al. (1990) conducted a landmark randomised crossover trial demonstrating that 25g of defatted fenugreek seed powder incorporated into food significantly reduced fasting blood glucose (from 255.6 to 196.0 mg/dL), postprandial glucose, glucosuria, and serum total cholesterol and triglycerides in patients with insulin-dependent diabetes mellitus [43].

Subsequent trials have extended these findings to T2DM. Gupta et al. (2001) demonstrated in a prospective randomised study of 25 T2DM patients that 1g/day hydroalcoholic fenugreek seed extract significantly improved insulin resistance (assessed by HOMA-IR) and reduced fasting blood glucose after 2 months [44]. A systematic review and meta-analysis by Neelakantan et al. (2014), encompassing 10 RCTs and 278 participants, conclusively established the blood glucose-lowering efficacy of fenugreek supplementation in T2DM patients [36].

For Centella asiatica, a clinical trial by Incandela et al. (2001) demonstrated improved microvascular parameters in diabetic patients, an effect attributed to its anti-oxidant and anti-inflammatory triterpenoids [45]. A more recent investigation by Gray et al. (2018) in older adults demonstrated dose-dependent improvements in cognitive function and cerebrovascular parameters, indirectly supporting its role in mitigating diabetic neuropathy and vascular complications [46].

The anti-obesity evidence for *Sushrutokta Shak Varga*, while less extensive than anti-diabetic data, is mechanistically compelling and growing. A randomised double-blind trial by Chevassus et al. (2010) demonstrated that a galactomannan extract from fenugreek seeds significantly reduced fat consumption (by 17%) and energy intake in healthy overweight male volunteers over a 14-day intervention, an effect mediated through enhanced satiety and reduced appetite scores [47].

The role of dietary patterns incorporating multiple low-GI, high-fibre vegetables (as would be characterised by an Ayurvedic dietary regimen emphasising Shak Varga) in obesity management is supported by large-scale epidemiological data. The PREDIMED study demonstrated that dietary patterns with low glycaemic load and high vegetable content were associated with 30% lower risk of type 2 diabetes and significant reductions in waist circumference and BMI over a median 4.8-year follow-up [48].

Similarly, the DIRECT trial established the superiority of low-glycaemic-load dietary patterns over low-fat diets for weight reduction and metabolic improvement [49].

5.7. Ayurvedic Pharmacological Properties and Moden corelation

Ruksha Guna (drying property) and Fluid/Lipid Dynamics

The Ruksha Guna (dryness quality), prominently attributed to Chakramarda and Vastuka, is pharmacologically relevant to the pathophysiology of *Prameha* , characterised by excessive fluid production and lipid accumulation. The diuretic, anti-oedematous, and lipid-regulatory properties of these vegetables, mediated through flavonoids and phenolic acids, align with the clinical applications of Ruksha dravyas in reducing Kleda (excessive moisture) and Meda (fat tissue) accumulation in *Prameha* (DM) [50].

Lekhan Guna (Scrapping property) and Lipolysis

The Ayurvedic concept of Lekhana karma, attributed to several *Sushrutokta Shak Varga* vegetables, implies the capacity to mobilise and eliminate accumulated body fat and morbid Kapha Dosha. In modern biochemical terms, this correlates with demonstrated lipolytic and anti-lipogenic activities: inhibition of fatty acid synthase (FAS) by flavonoids present in Centella asiatica and Brahmi [51]; activation of hormone-sensitive lipase (HSL) and adipose triglyceride lipase (ATGL) by fenugreek saponins [52]; and pancreatic lipase inhibition by Cassia tora anthraquinones [41]. The cumulative evidence validates Lekhana karma as a multi-pathway pharmacological property with molecular basis in anti-adipogenesis, lipolysis promotion, and inhibition of dietary fat absorption.

Agnideepana and Metabolic Stimulation

The property of Agnidipana (enhancement of digestive fire/metabolic rate) attributed to fenugreek, Centella asiatica, and Cassia tora finds modern correlates in: thermogenesis stimulation via uncoupling protein-1 (UCP-1) upregulation in adipose tissue by fenugreek flavonoids [53] ; enhancement of basal metabolic rate through thyroid hormone modulation by Brahmi bacosides [54]; and improvement of mitochondrial biogenesis via AMPK-PGC-1α pathway activation by asiatic acid [55]. These findings collectively support the Ayurvedic rationale for employing Agnidipana herbs in the management of *Sthaulya* and *Prameha*.

6. Conclusion

This comprehensive critical evaluation conclusively demonstrates that *Sushrutokta Shak Varga* occupies a clinically significant position in the nutritional management of obesity and type 2 diabetes mellitus, supported by multiple tiers of scientific evidence. The collective properties of these vegetables—characterised by uniformly low GI values (15–28), low glycaemic loads, high dietary fibre content (1.8–2.7 g/100g), low caloric density (19–49 kcal/100g), and rich micronutrient profiles—align precisely with the nutritional requirements for effective glycaemic control and weight management.

The diverse phytochemical constituents, including galactomannans, trigonelline, bacosides, asiaticosides, anthraquinones, and flavonoids, exert multi-target anti-diabetic and anti-obesity effects through mechanisms encompassing α-glucosidase inhibition, insulin secretagogue activity, GLUT-4 upregulation, AMPK activation, PPARγ modulation, adipogenesis inhibition, pancreatic lipase inhibition, and appetite regulation—providing a mechanistic basis for the Ayurvedic classification of these vegetables under therapeutic dietary categories for *Prameha* and *Sthaulya*.

These vegetables are culturally integrated, cost-effective, widely cultivated, and free from clinically significant adverse effects at dietary consumption levels. Their systematic incorporation into dietary guidelines for T2DM and obesity management in South Asian populations—as supported by the ancient Pathya-Apathya (wholesome-unwholesome) dietary framework of Ayurveda and now by modern nutritional science—represents a pragmatic and evidence-aligned clinical recommendation.

Future research should prioritise high-quality whole-food RCTs, bioavailability studies post culinary processing, and microbiome investigations to further consolidate the evidence base for integrating *Sushrutokta Shak Varga* into mainstream clinical nutritional guidelines for metabolic disease management.

Declarations

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Data Availability: All data supporting the findings of this review are available from published literature cited within the manuscript.

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