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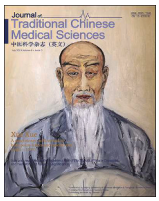

Review Article

Beyond pharmaceuticals: Integrating Chinese culinary medicine with modern nutritional science for holistic diabetes management

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ABSTRACT

The prevalence of diabetes mellitus in China has increased from <1% in 1980 to 13.7% in 2023, parallel to the adoption of a western-style diet. Chinese medicine (CM) approaches diabetes differently through food therapy, which is more holistic than the reductionist focusing on the bioactive compounds found in modern nutritional science. Herein, we review the CM and modern nutritional approaches to diabetes of five regional Chinese cuisines: Sichuan, Cantonese, Shandong, Hunan, and Jiangsu. A literature review of PubMed, Web of Science, China National Knowledge Infrastructure, and other medicine-specific databases was conducted, including papers from 2014 to 2024 and foundational CM literature. The inclusion criteria were systematic reviews, clinical trials, population studies, and mechanistic studies of Chinese dietary patterns and diabetes outcomes. In several studies, CM food therapy demonstrated clinical outcomes comparable to those of western dietary interventions, with the added advantage of fewer reported adverse effects. CM food therapy operates through five main mechanisms: glucose transport enhancement, glycogen metabolism improvement, glucagon-like peptide 1 secretion promotion, pancreatic islet protection, and intestinal flora modulation. Regional Chinese cuisine contains many bioactive compounds with established anti-diabetic effects. Sichuan capsaicin enhances insulin sensitivity by activating the AMP-activated protein kinase pathway. The fermented components of Hunan cuisine support gut microbiota; fresh food preparations of Cantonese cuisine are rich in antioxidants; and traditional dietary patterns are more protective against diabetes than westernized dietary patterns. A combined approach of CM and Western medicine offers the best potential for managing diabetes, as the cuisine from each area has distinct therapeutic value. Blending age-old food therapy with contemporary nutrition provides a rational basis for clinical integration.

1. Introduction

China has been strongly affected by the globalization of the diabetes epidemic, which has increased diabetes prevalence from <1% in 1980 to an age-standardized prevalence of 13.7%, 95% confidence interval 12.6%–14.8%, in 2023, a nearly 14-fold increase.[1] This steep rise correlates with China's economic status as it transitions from traditional domestic cuisine to westernized cuisine.[2] Chinese medicine (CM) has considered diabetes mellitus, a disease known as *xiaoke*, for over 2000 years through complex dietary therapy rules, as outlined in *The Yellow Emperor's Canon of Medicine* (*Huang Di Nei Jing*) and *Shennong's Herbals* (*Shen Nong Ben Cao Jing*), and in classical texts.[3] In modern CM practice, *xiaoke* is diagnosed based on clinical manifestations such as excessive thirst, hunger, urination, and weight loss (three excesses and one loss), along with tongue and pulse assessments. Syndrome differentiation further classifies the conditions into stages, such as heat, deficiency, and damage.

The paradigm gap between CM and modern nutrition is more than a matter of philosophy; it is a distinctive feature of the two contrasting eating approaches aimed at achieving the healing effects of food. CM views diabetes as a yin deficiency and dry-heat disorder, characterized by the selection of balance-recovery foods determined by their thermal properties, flavors, and the aforementioned organ functions.[4] In contrast, modern

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nutritional science primarily focuses on the molecular mechanisms of bioactive compounds, which entails phytochemical research, examining how an individual interacts with glucose homeostasis, insulin sensitivity, and metabolic pathways.[5]

New findings (systematic reviews) demonstrate that CM methods, previously thought to have less clinical efficacy than their western counterparts, show equal therapeutic results but with minimal adverse effects. Such medicines function through various mechanisms, such as enhancing glucose transport, favoring glycogen metabolism, and modulating gut microbiota.[6] Regulation of the gut microbiome for glucose homeostasis occurs through multiple pathways. Beneficial bacteria produce short-chain fatty acids that enhance insulin sensitivity, improve intestinal barrier function, reduce inflammatory endotoxin absorption, and modulate incretin hormone production, particularly glucagon-like peptide 1 (GLP-1), which stimulates insulin release and delays gastric emptying, collectively optimizing postprandial glucose control. Studies have also evaluated numerous traditional Chinese ingredients and identified active substances, such as berberine, capsaicin, and gingerol, that help control diabetes.[7] The convergence highlights opportunities to combine modern nutritional science with age-old therapeutic dietary traditions, allowing them to complement each other.

Chinese food approaches in different regions are localized because the diet is being influenced by geographical location, climate, and cultural background. This review focuses on Sichuan, Cantonese, Shandong, Hunan, and Jiangsu cuisines because they are five of the eight great cuisines of China, representing the most influential and diverse culinary traditions, each with distinct ingredient profiles, cooking methods, and historical ties to medicinal food practices.

The basis of Sichuan cuisine's signature ma—la (numbing and spicy) flavor is the presence of capsaicin, which contains hydroxyl-sanshool compounds that exhibit glucose-lowering properties.[8] Cantonese cuisine relies on fresh preparations, keeping antioxidants and bioactive components intact.[9] Shandong's sophisticated cooking techniques and high-quality ingredients provide balanced macronutrient profiles, featuring protein sources from seafood and lean meat that support metabolic health when portion sizes are appropriately managed.[10] Natural fermented foods from Hunan cuisine can boost gut health through the addition of probiotics.[11] Jiangsu cuisine's unique cooking styles, alongside the use of the freshest and seasonal ingredients, ensure maximum nutrient density in meals.[12]

The reason for comparing traditional Chinese and western dietary patterns is that dietary patterns characteristic of certain Chinese eating habits have been shown to be protective against non-communicable diseases, such as diabetes, cardiovascular disease, obesity, and metabolic syndrome. In contrast, westernized diet patterns have been shown to increase the risk. In a Singapore Chinese health study, a diet rich in vegetables, fruits, and soy was shown to reduce the risk of diabetes by 25%, whereas a diet rich in meat increased the risk by 47%.[13] Understanding how traditional food therapy principles align with modern nutritional science may inform evidence-based integrative approaches to diabetes prevention and management.

2. Methodology

A thorough literature search was conducted on PubMed/Medline, Wanfang Data, China National Knowledge Infrastructure, Web of Science, and the Scopus and Google Scholar databases. The terms “Chinese medicine,” “diabetes mellitus,” “food therapy,” “Chinese cuisine,” and “regional dietary patterns” were searched. The search included peer-reviewed articles published between 2014 and 2024, along with fundamental CM books and their updated versions. Systematic reviews, meta-analyses, randomized controlled trials, population studies, and mechanistic studies focusing on Chinese dietary patterns related to diabetes were included. Studies were ranked according to their methodology, sample size, and relevance to the research objectives. Classical CM texts were considered for their historical and theoretical context, with a focus on modern translations and interpretations by recognized CM scholars. Conflicting findings were evaluated through a narrative synthesis that considered the study design, sample size, consistency with known mechanisms, and clinical relevance to diabetes management. The synthesis of the evidence was performed narratively, comparing CM with western perspectives on each regional cuisine to determine their converging and diverging mechanisms. The analysis focused on the clinical evidence, mechanistic understanding, and practical applications related to diabetes care.

3. Theoretical foundations

3.1. Chinese medicine perspective on diabetes

In CM practice, diabetes is referred to as *xiaoke*, or “wasting and thirsting disease,” which was first noted in *The Yellow Emperor's Canon of Medicine*.[14] The classical etiology regards yin deficiency and dryness-heat as the central pathophysiological mechanism, whereby the cooling, nourishing yin essence is exhausted, leading to a relative surplus of heating yang energy.[15] This syndrome is expressed by the “three excessive and one loss” pattern: excessive drinking and eating, urination, and weight loss. Modern CM has four distinct disease stages: stagnation (pre-diabetes), heat (early-middle diabetes), deficiency (advanced diabetes), and damage (complications).[16] These shifts illustrate the transition from acute to chronic excess patterns to chronic deficiency states, necessitating the use of different treatment strategies.

Food therapy in CM involves advanced classification systems that categorize food based on its thermal properties (four natures), flavors (five tastes), and affinities to organ systems (meridian tropism). The four natures classify foods as cold, cool, neutral, warm, or hot, with diabetes requiring cool and cold foods to clear the heat and nourish the yin.[17] The five tastes include sweet, bitter, sour, pungent, and salty, which exert therapeutic actions, among which, bitter foods are prized for their heat-clearing and dampness-removing properties.[18] Recent clinical studies have confirmed the value of older methods, and systematic reviews have shown that CM food therapy achieves comparable control of blood glucose levels to Western medicines, along with enhanced quality of life, fewer complications, and fewer adverse effects.[19] Examples of commonly recommended ingredients include *Momordica charantia* L. (*M. charantia,* Ku Gua, bitter melon), *Nelumbo nucifera* Gaertn. (*N. nucifera*, Lian Ou, lotus root), *Dioscorea polystachya* Turcz. (*D. polystachya*, Shan Yao, Chinese yam), *Vigna radiata* (L.) R. Wilczek (*V. radiata*, Lyu Dou, mung beans), sea cucumber, *Auricularia heimuer* F. Wu, B. K. Cui & Y.C. Dai (*A. heimuer*, Hei Mu Er, black fungus) and *Hordeum vulgare* L. (*H. vulgare*, Da Mai, barley), which play both nutritional and therapeutic roles in managing blood glucose levels and supporting organ function in CM. This multi-target approach addresses both the symptoms and underlying factors because diabetes is a complex metabolic disorder requiring holistic treatment.

3.2. Modern nutritional science perspective

The western approach to diabetes management focuses on the study of specific metabolites, their associated processes, and their

consequences. Specific nutrients and phytochemicals are studied for their insulin- and glucose-related health effects on the body over time.[20] Critical mechanistic pathways include stimulated incretin action through GLP-1 secretion, translocation of glucose transporter type 4 (GLUT4), which enhances glucose transport, and activation of the AMP-activated protein kinase (AMPK)-mediated insulin signaling pathway.[21] Western studies have recognized some bioactive constituents of Chinese food as anti-diabetic, such as capsaicin, which improves insulin sensitivity, berberine with metformin-like actions, and catechin-driven enhancement of glucose uptake in skeletal muscles.[22]

The backbone of the evidence is derived from randomized controlled trials, systematic reviews, and published population-based research assessing dose–response relationships over extended timeframes. More recent meta-analyses have highlighted that traditional Chinese diets, which include vegetables, soy, and whole grains, reduce the risk of diabetes by 17%–25% compared to westernized versions of the diet.[23] Research on the gut microbiota has emerged as a crucial blend of old and new paradigms, where CM's ancient concepts of transforming dampness and harmonizing the spleen and stomach through fermented foods align with modern scientific understanding of how beneficial bacteria modulate glucose metabolism, produce therapeutic metabolites, and maintain intestinal barrier function. Certain traditional Chinese foods promote the growth of specific beneficial bacteria, which, in turn, improve glucose metabolism and reduce inflammation.[24] This understanding provides a mechanistic validation of traditional views about the role of food in "transforming dampness" and "strengthening spleen function." Fig. 1 shows the CM and modern nutritional understanding of diabetes and management approaches.

4. Regional cuisine analyses

Although each regional cuisine encompasses a wide range of dishes, this review focuses on representative ingredients and preparation methods traditionally recognized for their therapeutic relevance in both CM and modern nutritional science. We acknowledge the variability due to personal habits, local ingredient availability, and evolving culinary practices; thus, references to regional cuisines are illustrative rather than exhaustive.

4.1. Sichuan cuisine: ma–la therapeutic profile

The signature ingredients and methods of Sichuan cuisine provide, in addition to their culinary flavor, a distinct edge in diabetes management due to its unique ma–la flavor profile.

4.1.1. Cuisine characteristics

Sichuan cuisine is based on over 40 different cooking techniques and a blend of 24 flavor combinations. It features *Vicia faba* L. (*V. faba*, Can Dou, broad beans), doubanjiang (fermented broad bean paste), *Allium sativum* L. (*A. sativum*, Da Suan, garlic), *Zingiber officinale* Roscoe (*Z. officinale*, Jiang, ginger), and *Allium fistulosum* L. (*A. fistulosum*, Cong, scallions), along with *Zanthoxylum bungeanum* Maxim. (*Z. bungeanum*, Hua Jiao), Sichuan peppercorns, and dried *Capsicum annuum* L. (*C. annuum*, La Jiao, Chili pepper), which form the foundation of the dish.[25] Bao (flash frying), dry frying, braising, and steaming are some of the primary cooking techniques that aim to layer intricate flavors while maintaining the basic components of the dish.

The geographical and climatic environment of the region, combined with its culture, has shaped the development of its cuisine. This supports CM theory, which suggests that "warming" foods are a way to counteract dampness or cold, which may lead to impaired metabolic function. This explains why spicy foods, such as Sichuan peppercorns and dried chilies, are consumed to enhance circulation and combat humid weather.[26]

4.1.2. CM perspective

From the CM perspective, the spiciness of Sichuan cuisine highlights several pathogenic factors that contribute to diabetes. Chili peppers possess pungent and hot properties that aid in circulation, qi movement, and removing dampness, which is often associated with diabetes and metabolic syndrome.[27] The penetrating, sharp, and piquant flavor also directs qi into the respiratory system, facilitating breathing and fluid metabolism.

Sichuan peppercorn has distinct therapeutic effects owing to its numbing quality. CM connects this to blood stagnation and meridian opening. This process supports circulatory function and helps prevent diabetes complications, which are often characterized by poor circulation.[28] The blending of "ma" with "la" yields a balanced therapeutic action that addresses both qi stagnation and

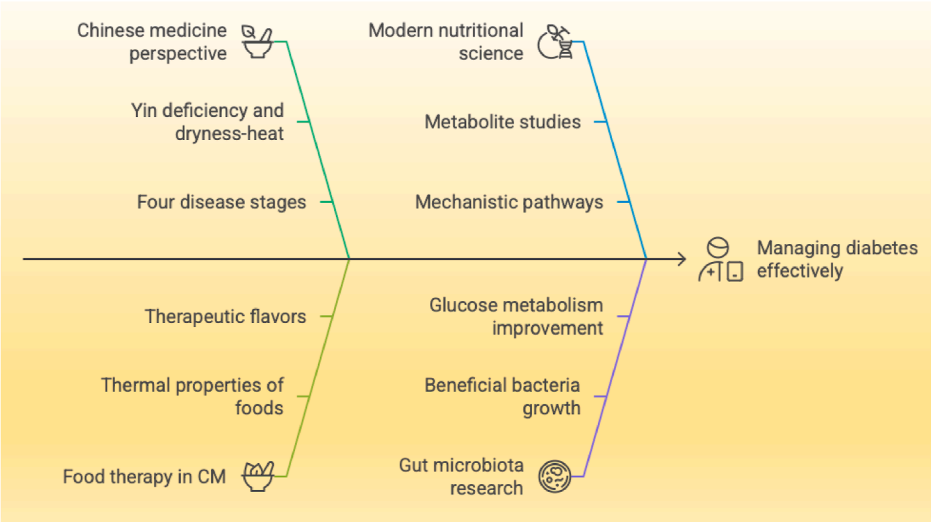

Fig. 1. CM and nutritional science understanding of diabetes management approaches.
Notes: CM: Chinese medicine.

blood stasis patterns associated with diabetes, specifically targeting poor circulation (blood stasis) and sluggish metabolism (qi stagnation), which contribute to insulin resistance and diabetic complications. The fermented ingredient, doubanjiang, possesses the ability to "transform dampness" and supports the digestive process. According to the CM theory, impaired digestion plays a key role in the development of diabetes, making such ingredients potentially beneficial for its management.[29]

4.1.3. Modern nutritional analysis

Western studies have uncovered numerous bioactive compounds in the ingredients used in Sichuan cuisine with anti-diabetic effects. The main bioactive compound in chili pepper, capsaicin, enhances insulin sensitivity via transient receptor potential vanilloid 1 (TRPV1) channels, AMPK pathways, and glucose uptake in skeletal muscles.[30] Clinical studies have shown that consuming 5 g of capsicum daily (which contains 26.6 mg capsaicin) significantly reduced plasma glucose levels during an oral glucose tolerance test in healthy subjects.[31] Studies conducted on diabetic animal models have also demonstrated that capsaicin enhances glucose tolerance, reduces the accumulation of visceral fat, and improves insulin secretion from pancreatic β-cells.[32]

Sichuan peppercorns contain hydroxyl-α-sanshool and hydroxyl-β-sanshool, which possess potent α-glucosidase inhibitory activity, exhibiting IC_{50} values (a measure of the concentration required to inhibit 50% of enzyme activity) of 9.5 and 18.6 μg/mL, respectively. These sanshool compounds are 13–25 times more potent than acarbose,[33] as indicated by their lower IC_{50} values, where lower values reflect higher potency. This demonstrated that small amounts of these Sichuan compounds can effectively reduce carbohydrate digestion and subsequent glucose absorption. These compounds may reduce postprandial spikes in glucose concentrations after meals by inhibiting carbohydrate digestion. Fermented foods contain probiotics that are beneficial to the gut flora. Emerging research has shown that the diversity of gut bacteria is associated with a reduced risk of diabetes and improved glucose metabolism.[34]

4.1.4. Comparative synthesis

The integration of Chinese and western perspectives on Sichuan cuisine reveals a remarkable overlap in their therapeutic approaches. The CM concepts of stagnated blood and qi relate to western studies on the impact of spicy food on circulation and metabolism. The pepper's ability to help dispel dampness corresponds to contemporary knowledge regarding its potential to reduce visceral fat and improve insulin sensitivity.

Despite there being some agreement in thinking, CM and western science have different reasons for considering fermented foods important for diabetes management. CM emphasizes the importance of "transforming dampness," whereas western science focuses on probiotics and gut health. The multi-compound strategy of Sichuan cuisine is beneficial for the treatment of diabetic complications. Capsaicin, sanshool, and fermented products achieve several therapeutic objectives that cover various stages of the pathophysiology of diabetes.

4.2. Cantonese cuisine: fresh preparation & therapeutic advantages

The philosophy of diabetes management and nutrition offers several valuable advantages to the Cantonese cooking style, which emphasizes natural flavors and the use of fresh ingredients.

4.2.1. Cuisine characteristics

The quality of the ingredients used in a dish is central to Cantonese cuisine, as highlighted by the saying, "eating is in Canton," which shows appreciation for good food.[35] This cooking style features fresh seafood, seasonal vegetables, and the subtle addition of soy sauce, oyster sauce, ginger, and scallions. The primary methods of cooking include steaming, light stir-frying, braising, and roasting, with steaming being the most favorable because it retains many natural flavors and nutrients of the food.

The dim sum tradition illustrates this philosophy, as small servings of various dishes are provided, which helps control portions while ensuring nutritional variety. These principles align with modern recommendations for diabetes management.[36]

4.2.2. CM perspective

From a CM perspective, the fresh and lightly prepared foods of Cantonese cooking support the practice of "eating seasonally" as well as the balance between cooling and warming properties.[37] The highlight of this cuisine is fresh seafood, which is abundant and serves as a rich source of high-quality protein that supports kidney function. Coupled with seasonal vegetables, a harmonious blend of nutrients is provided for the body.

The preferred steaming method in Cantonese cooking is a form of shallow poaching that protects the natural qi of food and prevents excessive dryness, which, in CM theory, can worsen diabetes.[38] Lightly seasoned steamed dishes also prevent overpowering of the natural flavors of the ingredients, enabling their therapeutic properties to be fully unleashed. The emphasis on seasonal vegetables aligns with CM theories regarding food consumption during their natural harvest, providing balanced nutritional and energy benefits.[39] Bok choy, bitter melon, and other vegetables used in Cantonese cuisine have cooling effects that clear excess heat while nurturing yin.

4.2.3. Modern nutritional analysis

The preservation of the bioactive components and optimal nutrient profiles of Cantonese food make it a living cuisine in modern biomedicine. Nutritionally, steaming is the best cooking method because it retains water-soluble vitamins and antioxidants,[40] which are often lost during other cooking methods. Consuming fresh seafood also has advantages since it is a rich source of proteins with ideal amino acids and omega-3 fatty acids, which promote insulin sensitivity and help reduce inflammation.[41] Studies have demonstrated that regular fish consumption reduces the risk of diabetes by 7%–12% in Asian populations.[42]

Cantonese seasonal vegetables have been shown to contain polyphenols, carotenoids, and other antioxidants that support glucose metabolism, as well as antioxidant properties that prevent complications associated with diabetes,[43] thereby protecting against the disease. Chinese broccoli and watercress contain glucosinolates with anti-diabetic properties.[44] The wide array of cooking methods used in Cantonese cuisine, from raw to gentle steaming, helps minimize the creation of advanced glycation end products that can worsen diabetes outcomes,[45] while preserving water-soluble vitamins and antioxidants that degrade under intense heat.

4.2.4. Comparative synthesis

Both CM and western perspectives acknowledge the health benefits of Cantonese cuisine, stemming from the use of fresh ingredients and light cooking techniques. CM attempts to maintain natural qi align with western approaches to preserve bioactive compounds. The seasonal eating principle is aligned with contemporary nutrition, which advocates food consumption based on nutrient density. The natural portion control in this type of cuisine, achieved through the dim sum custom, aligns with the moderation principles of CM and modern nutritional science guidelines for diabetes management, emphasizing portion control,

dietary variety, and the beneficial practice of consuming multiple small dishes rather than large single portions.

4.3. Shandong cuisine: sophisticated techniques for metabolic health

Shandong cuisine has gained recognition in the field of diabetes management because of its emphasis on protein-rich dishes rich in umami prepared using sophisticated techniques.

4.3.1. Cuisine characteristics

Shandong cuisine is renowned for its skilled knife work and distinctive cooking techniques, including deep-frying and steaming. Dishes contain seafood and scallions[46] and focus on salty, sweet, and sour flavors. Some of the techniques used include flash frying, referred to as "bao," braising, where "pa" is used, and coating with starch, known as "ta." The historical association with imperial cuisine has created a tradition of refinement and precision that maximizes ingredient potential while creating balanced and satisfying meals.[47]

4.3.2. CM perspective

From the CM perspective, the sophisticated use of animal-based proteins and clear broths in Shandong cuisine adheres to the philosophy of "nourishing without causing stagnation."[48] The abundant scallions provide pungent flavors that assist with qi and circulation; additionally, the emphasis on seafood helps nourish the kidney essence. CM principles are reflected in the cuisine's balance of flavors with different taste elements, as salty flavors support kidney function, sweet elements nourish the spleen, and sour components preserve body fluids.[49] In Shandong cuisine, clear broths provide hydration and nutrients that support digestion, which is a crucial aspect of managing diabetes in CM.[50] This balanced approach promotes metabolic health and targets several aspects of the pathophysiology of diabetes, specifically digestive weakness, kidney dysfunction, and circulatory stagnation, as defined in CM, which correspond to insulin resistance, fluid metabolism disorders, and vascular complications in modern medicine.

4.3.3. Modern nutritional analysis

Previous studies have shown the therapeutic benefits of Shandong cuisine owing to its high-protein and low-carbohydrate seafood and meat dishes, along with its meticulous cooking practices that retain nutrients. Quality seafood and lean meat contain proteins and have beneficial amino acid profiles that aid glucose metabolism and enhance insulin sensitivity.[51] The focus of Shandong cuisine on aged vinegar garnishes provides acetic acid, which is known to improve postprandial glucose levels and significantly enhance insulin sensitivity.[52] Research shows that consuming two tablespoons of vinegar before meals can lower the glucose surge after meals by 20%–30%.[53] Shandong's sophisticated cooking strategies enable the retention of nutrients and improve meal satisfaction. Macronutrient ratios align with diabetes management strategies, which recommend controlled carbohydrate intake and adequate protein consumption.[54]

4.3.4. Comparative synthesis

The link between CM and western approaches focusing on Shandong cuisine is based on the medicinal benefits of high-quality proteins and balanced nutrition. Both approaches appreciate the value of hearty, well-balanced meals that enhance metabolism, considering the optimal nutrients and cooking methods that preserve essential therapeutic compounds.

4.4. Hunan cuisine: fermented foods and metabolic benefits

The therapeutic benefits of Hunan cuisine stem from its unique use of fermented and preserved foods, which aid in diabetes management through the gut microbiota and bioactive compounds.

4.4.1. Cuisine characteristics

Hunan cuisine is characterized by a focus on the "gan la" (dry and spicy) flavor profile featuring fresh chili peppers, vinegar-based sauces, fermented black beans (douchi), and pickled vegetables.[55] Hunan cuisine was developed under the influence of a humid climate, which requires advanced food preservation techniques, thus, creating a rich tradition of fermented foods that offer enhanced flavor and health benefits. Key culinary techniques include smoking, fermentation, pickling, and stewing, which are employed in seasonal menus based on the availability of fresh ingredients and need for preservation.[56]

4.4.2. CM perspective

From the CM perspective, Hunan cuisine fermented foods aid in digestion by "transforming dampness" and "strengthening the spleen," which are important to help with diabetes management.[57] Fermented black beans and pickled vegetables undergo changes that enhance their health benefits and make them more easily digestible for individuals with diabetes. The chilies used in this cuisine are spicy and differ from those used in Sichuan cooking. Fresh food offers different therapeutic benefits as they provide more cooling properties to balance the heat produced by the fermentation process during digestion.[58] This delicate equilibrium between heat and dampness is sophisticated. The seasonal dietary habits incorporated in Hunan cuisine align with CM theories on diets that adapt to climatic conditions, thus, promoting health and preventing illness.[59]

4.4.3. Modern nutritional analysis

Previous studies have demonstrated the health benefits of Hunan cuisine through the therapeutic use of fermented foods and bioactive compounds. Probiotic black beans have been shown to improve gut health and glucose metabolism through bioactive peptides.[60] The consumption of fermented soy reduces diabetes risk by 17% in Asian populations.[61] Fresh peppers in Hunan cuisine, similar to those used in Sichuan dishes, contribute to metabolic benefits and antioxidant intake,[62] particularly when combined with fermented foods.[63] Pickled and fermented vegetables improve the gut microbiota diversity. There are beneficial strains of bacteria that can be derived from these foods, which have been shown to improve glucose tolerance and insulin sensitivity.[64] The fermentation process has many advantages, as it enhances the availability of specific nutrients while simultaneously producing beneficial metabolites.[65] Although many mechanistic insights have been revealed from in vitro and animal studies, emerging human clinical trials have begun to support the role of fermented foods in improving glycemic control and modulating the gut microbiota in patients with type 2 diabetes, indicating translational potential.

4.4.4. Comparative synthesis

Both CM and western research approaches recognize the health benefits of Hunan cuisine, which is derived from fermented foods and spicy, fresh ingredients. The classical "transforming dampness" theory aligns with contemporary views on how probiotics enhance metabolic function and inflammation.

4.5. Jiangsu cuisine: refined preparations for optimal nutrition

The use of intricate methods in Jiangsu cuisine, coupled with the proper use of seasonal ingredients, ensures the highest nutritional and therapeutic value in managing diabetes.

4.5.1. Cuisine characteristics

Jiangsu cuisine, also referred to as "national cuisine," places great importance on the selection of seasonal ingredients, artistry in food presentation, and a hierarchy of cooking skills.[66] The cuisine includes freshwater fish, seasonal vegetables, lotus roots, and refined broths. These are prepared by gentle braising and steaming with precise temperature control. The four regional styles—Huaiyang, Jinling, Suxi, and Xuhai—offer distinct techniques while remaining true to the overall philosophy of refinement and balance.[67]

4.5.2. CM perspective

From the CM perspective, Jiangsu cuisine exemplifies the concept of "nourishing essence through gentle methods," which has cultivated balance in health systems over time.[68] The use of lotus root aligns with CM principles that support the consumption of seasonal foods. Its cooling properties, which clear heat and nourish yin, make it particularly beneficial for diabetes management.[69] The use of freshwater fish allows easier digestion compared to heavier proteins, providing kidney-nourishing properties. Gentle cooking methods enhance the digestibility of foods, making them easier for patients with diabetes, who often have impaired digestion. This supports the natural qi of ingredients and gentle cooking methods.[70]

4.5.3. Modern nutritional analysis

Research has confirmed the health benefits of Jiangsu cuisine, particularly the lotus root, owing to its anti-inflammatory polyphenols and dietary fiber, as well as the cuisine's overall nutrient preservation and careful ingredient selection.[71] Further studies have demonstrated that regular consumption of lotus root improves insulin sensitivity and reduces oxidative stress.[72] By focusing on seasonal vegetables, the consumption of cuisine is maximized when the nutrient density is highest, dramatically enhancing the value of vitamin, minerals, and antioxidants.[73] Meticulous cooking methods enhance taste, increase satiety, and preserve heat-sensitive nutrients.[74] Freshwater fish are generally safer than marine fish because they are mercury-free and rich in high-quality proteins and beneficial fatty acids, making them a suitable choice for diabetes management.[75]

4.5.4. Comparative synthesis

The convergence of Chinese and western perspectives on Jiangsu cuisine highlights the health benefits associated with gentle cooking techniques and the importance of eating in harmony with the seasons. Both schools of thought acknowledge that sophisticated cooking methods enhance the healing benefits of ingredients while producing nutritionally rich meals. Fig. 2 shows the therapeutic benefits of the various Chinese cuisines discussed in this section.

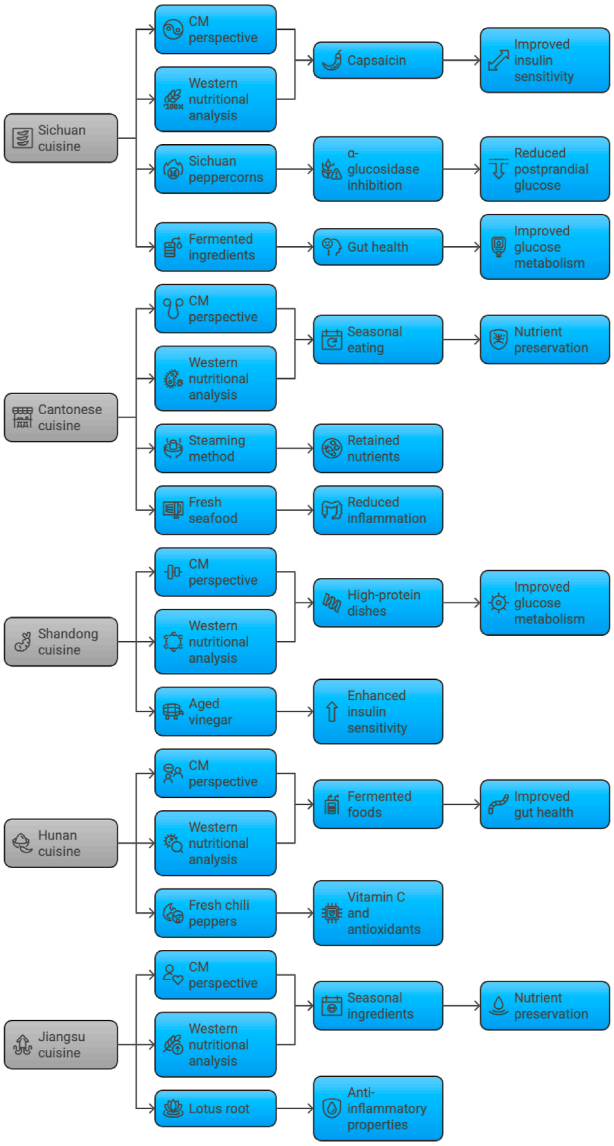

Fig. 2. Therapeutic benefits of Chinese cuisines.
Notes: CM: Chinese medicine.

5. Cross-regional synthesis

5.1. Convergent mechanisms across cuisines

Examination of five regional cuisines from China revealed several common mechanisms supporting diabetes management within different culinary traditions. Fermentation has emerged as a common theme, with Sichuan's doubanjiang, douchi from Hunan, and several pickled vegetables providing beneficial probiotics for gut and glucose metabolism.[76] This supports the growing evidence of a correlation between gut microbiota diversity, improved metabolic health, and reduced risk of diabetes.[77] Spicy and pungent ingredients, such as chili, garlic, and ginger, are common across multiple cuisines and collectively contribute to improved metabolic function as previously described.[78] The CM explanation of pungent flavors as tools to move qi and improve circulation agrees with recent evidence on the impact of these compounds on metabolism and blood flow.[79]

The focus on seasonal ingredients is another shared theme, with all cuisines valuing fresh produce. This approach optimizes nutrient density consistent with the CM concept of environmental harmony, as well as modern nutritional science focused on bioactive compounds. The seasonal approach also increases dietary variety, as promoted by modern diabetes management guidelines for nutrition and long-term adherence.[79,80] The complexity of cooking methods in all cuisines stems from the shared principle of preserving the essence of ingredients while

enhancing the depth of flavors. Some techniques, such as steaming and braising or gentle stir-frying, are nutritious and help create palatable and satisfying meals that support dietary compliance,[81] addressing a primary concern in diabetes care dynamics: enjoyable, sustainable, and long-term dietary patterns that patients can adhere to.[82] Fig. 3 shows the effects of various elements of Chinese cuisine on diabetes management.

5.2. Divergent approaches and complementary benefits

Although there are similarities, the differences in cuisines among regions offer various therapeutic approaches. Different cooking methods provide diverse solutions for the different types of diabetes. The heating properties of Sichuan cuisine benefit patients with cold and dampness patterns, and the cooling preparations of Cantonese cuisine benefit those with heat patterns.[83] This personalized approach aligns with the constitutional differences and syndrome differentiation focus of CM.[84]

Macronutrient profiles differ greatly among regions. Shandong cuisine focuses on high-protein preparations, Cantonese cuisine emphasizes balanced protein and vegetable combinations, and Jiangsu cuisine features nutrient-dense preparations of fiber-rich vegetables and lean freshwater proteins. Hunan cuisine, which includes fermented vegetables and fresh chilies, offers microbiota-

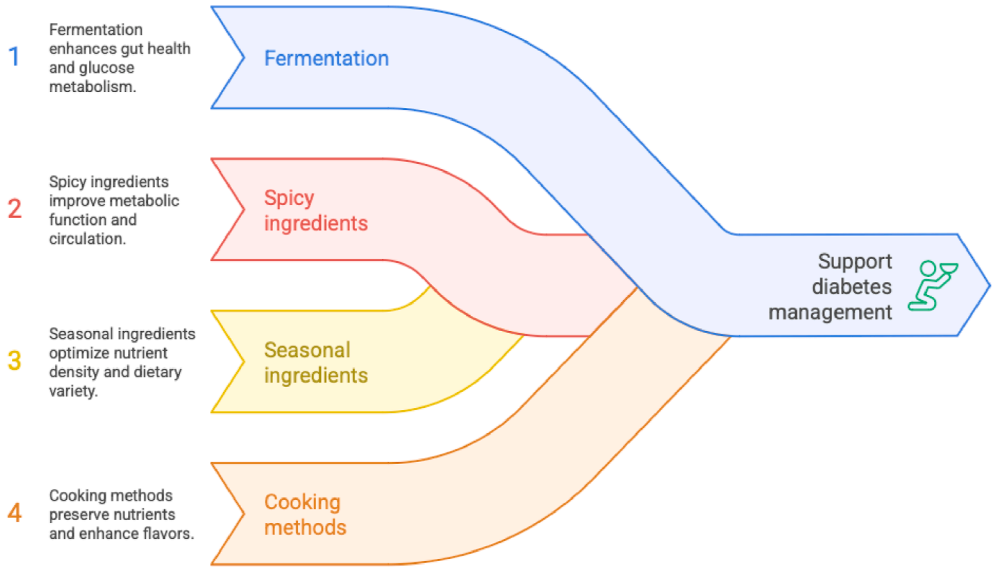

Fig. 3. Impact of Chinese cuisine elements on diabetes management.
Notes: AMPK: AMP-activated protein kinase.

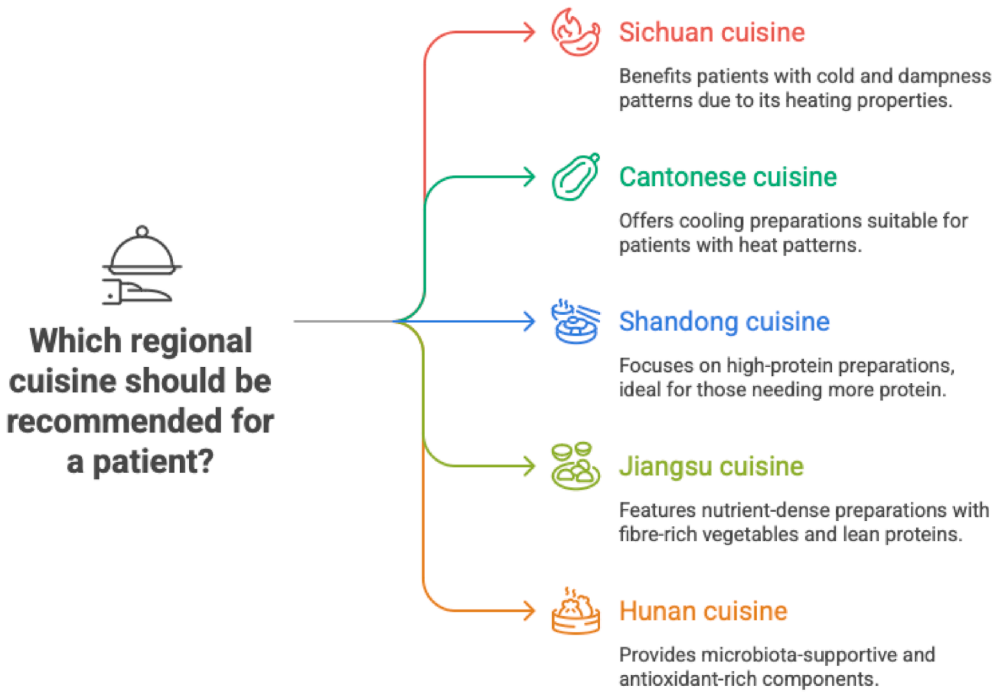

Fig. 4. Choice of Chinese cuisine for dietary needs.

supportive and antioxidant-rich components that add further nutritional diversity. Such differences enable personalized dietary strategies tailored to individual metabolic needs and personal preferences.[85] Simplicity, as seen in the fresh preparations of Cantonese cuisine, contrasts with the sophisticated cooking techniques of Jiangsu cuisine. This diversity caters to different lifestyles, including busy urban dwellers who prefer simpler cooking methods, and those with ample time dedicated to complex cooking.[86]

Different cuisines that preserve dietary diversity for people with diabetes help alleviate psychological monotony, while also addressing dietary monotony (Fig. 4). Diverse flavor profiles help prevent dietary monotony. Research has demonstrated that flavor variety supports long-term adherence and enhances the quality of life of patients with diabetes.[87]

5.3. Integration opportunities

Regional Chinese cuisines can be incorporated into western medical methods in several possible ways for managing diabetes. Personalized CM-based nutrition could augment western dietary counselling by utilizing traditional evaluations of an individual's thermal constitution and organ system strengths.[88] This method could improve dietary compliance by better aligning recommendations with patients' natural preferences and tolerances.[89] Optimization of bioactive compounds through traditional cooking can enhance the effectiveness of diabetic diets. For example, some vegetarian dishes from Hunan cuisine can be modified by incorporating greater amounts of probiotics through fermentation, while the spices from Sichuan can be used to increase the antidiabetic effects of the dishes.[90]

Seasonal eating protocols, grounded in traditional Chinese practices, can support western dietary guidelines by offering patients structured diet modification instructions for each season, while preserving the desired therapeutic effects.[91] This could help solve the issue of dietary monotony during long-term diabetes management.[92] Portion control and behavioral modification techniques aimed at reducing eating frequency could be balanced with mindful eating rituals rooted in Chinese culture, which values shared meals and the meticulous selection of fresh, high-quality ingredients.[93] Patients with diabetes who have better glycemic control and a higher quality of life have been found to benefit from mindful eating practices.[94]

6. Clinical implications and recommendations

6.1. Evidence-based integration strategies

Evidence from Chinese dietary medicine and contemporary nutritional science support the integration of strategies for diabetes management. Personalized dietary strategies that incorporate CM constitutional assessment alongside modern nutritional analysis may optimize treatment by simultaneously addressing biomarkers and individual constitutional considerations.[95] Clinical protocols should utilize syndrome differentiation for food selection and prescribe cooling foods to patients exhibiting heat patterns (often inflammatory) and warming foods to those with cold patterns (often digestive weakness).[96] This strategy can be coupled with conventional medical assessments, including those of inflammatory markers, gut microbiota, and metabolic profiling.[97]

Graduated implementation strategies follow an incremental approach, starting with simple changes, such as the addition of fermented foods and seasonal vegetables, which can be expanded to more extensive alterations.[98] This strategy addresses the problem of sustainable behavioral changes in diabetes management while providing patients with benefits that support further participation and engagement.[99] Combination therapy protocols should integrate CM food therapy with conventional medicine, monitor blood glucose levels, and adjust medications as necessary,[100] as shown in Fig. 5. Clinical evidence supports this strategy, in which the outcomes are enhanced, and medication requirements are reduced, thereby demonstrating its safety and efficacy.[101]

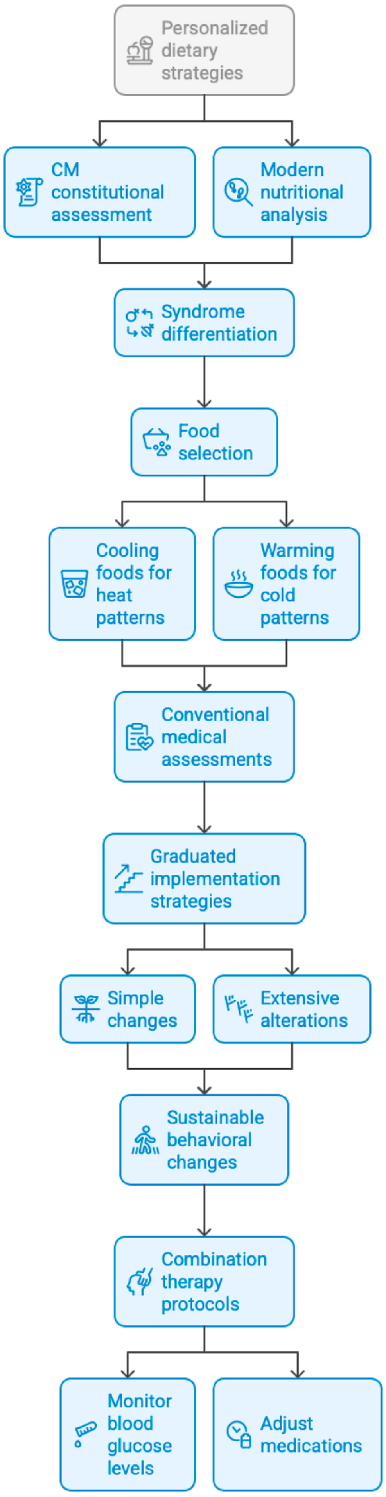

Fig. 5. Integrated diabetes management strategy.
Notes: CM: Chinese medicine.

6.2. Practical implementation guidelines

When utilizing integrated models of care in diabetes management, healthcare practitioners must follow specific practical guidelines, as shown in Fig. 6. Patient education should blend traditional concepts with modern, evidence-based practices to help patients appreciate how ancient beliefs combine with contemporary science.[102] This dual approach enhances patient confidence and adherence due to its cultural relevance and scientific validation.[103] Ideally, seasonal menu planning should incorporate eating patterns aligned with natural cycles, while addressing nutritional needs and glucose control.[104] This may entail spring detoxification diets utilizing bitter vegetables, summer cooling foods comprising fresh fruits and vegetables, autumn nourishing foods including warming spices, and protein-rich preparations for winter strengthening foods.[105]

Method training can assist patients in optimizing the therapeutic potential of their food through methods that preserve nutrients and enhance bioactive compounds.[106] This practical method bridges the gap between nutritional knowledge and dietary implementation.[107] Community-based programs that combine classes teaching traditional Chinese cookery, seasonal eating workshops, and the preparation of fermented foods can help provide social support while teaching practical skills.[108] Community-based interventions have been shown to improve long-term diabetes management.[109]

6.3. Monitoring and adjustment protocols

Integrated approaches require close observation as well as monitoring and adjustment protocols to ensure safety and efficacy, as shown in Fig. 7. Assessment should also include traditional markers, such as pulse and tongue examinations, along with blood glucose levels, hemoglobin A1c levels, lipid profiles, and inflammatory markers.[110] This approach enables a more comprehensive assessment of patient health and response to treatment.[111] Medication adjustment protocols should consider the interactions of traditional dietary and herbal medicines with conventional medications, particularly glucose-lowering herbs and supplements, which that may potentiate the effects of these medications.[112] Safe implementation requires collaboration between CM practitioners and conventional healthcare providers, which highlights the importance of interdisciplinary teamwork.[113] Traditional approaches, often associated with lower glucose levels, tend to improve numerous aspects of life; therefore, biomarker improvements should be performed alongside quality-of-life measures.[114] This supports the notion that holistic outcomes can be measured. This methodology reflects the growing emphasis on patient-centric care, which targets multiple dimensions of health and well-being.[115]

7. Future research directions

7.1. Mechanistic studies required

Further mechanistic research is required to fully understand the therapeutic potential of traditional Chinese diets. Understanding the interactions between bioactive compounds in traditional recipes requires furthermore investigation to understand how multiple compounds work synergistically to produce therapeutic effects.[116] This could help develop functional foods and nutraceuticals from traditional blends.[117] Studies on gut microbiota should focus on the impact of specific regional cuisines on bacterial diversity and metabolic function, particularly in relation to fermented foods and glucose metabolism.[118] This study may help provide tailored nutritional advice based on microbiome profiles.[119]

Pharmacokinetic studies of traditional food combinations may reveal how specific recipes or ingredient combinations affect the bioavailability and therapeutic activity of key components.[120] This information may help the establish optimal preparation guidelines for therapeutic benefits.[121] Epigenetic studies have focused on the effect of traditional dietary patterns on the regulation of genes associated with insulin sensitivity and diabetes-related complications,[122] which may help explain some long-term benefits that originate from traditional diets.[123]

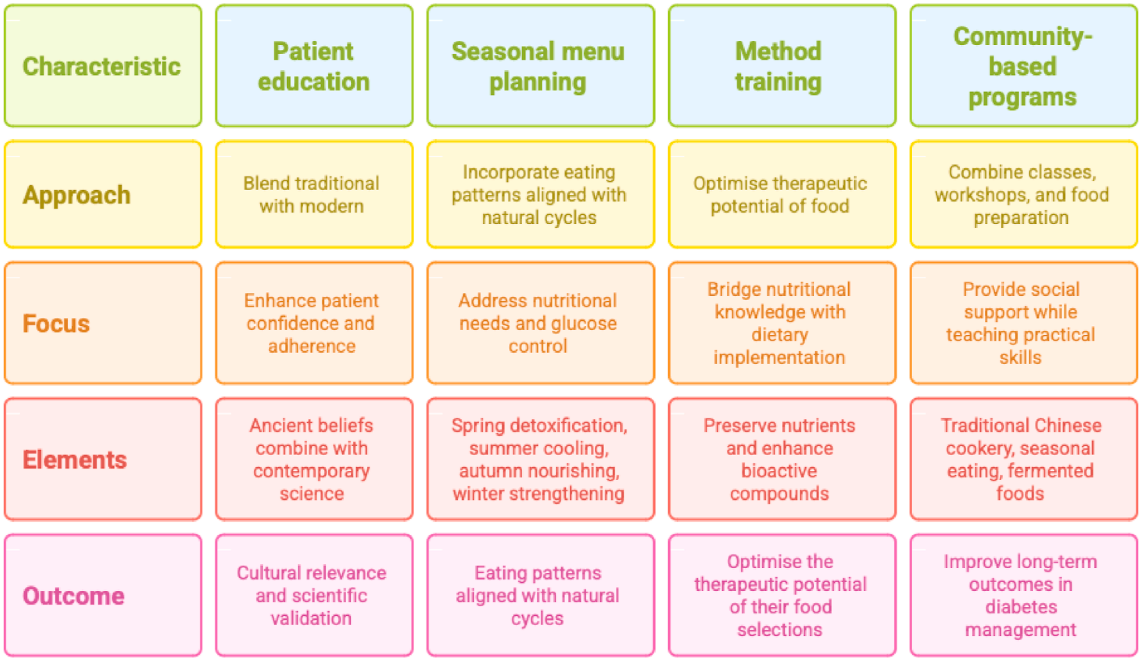

Fig. 6. Practical guidelines for integrated models of care in diabetes management.

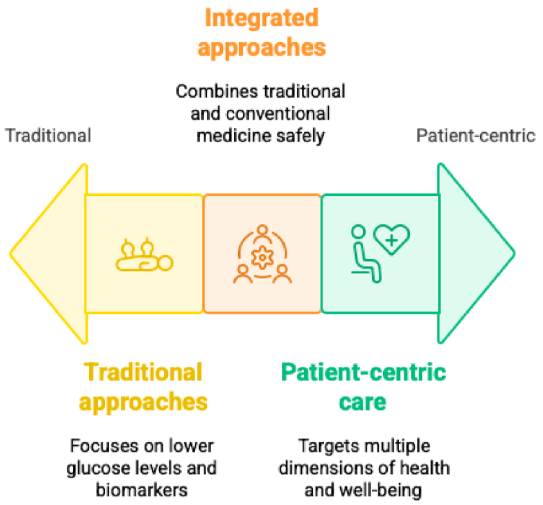

Fig. 7. Understanding healthcare approaches from traditional to patient-centric methods.

7.2. Clinical trial priorities

Optimal glycemic control is crucial for preventing long-term complications in patients with diabetes, and lifestyle interventions may be more cost-effective in the early management of diabetes than medications, which often yield better health outcomes.[124] Chinese and Western medicines represent two distinct healthcare paradigms, each with unique principles and practices.[125] Further clinical research is required to integrate modern therapeutic and traditional dietary methods as there are gaps in the evidence-based integration of these two approaches. Large-scale randomized controlled trials are necessary to establish clinical guidelines for the integrated versus conventional management of diabetes.[126] Studies on personalized medicine should investigate how an individual's genetic composition, microbiome, and constitution can inform optimal dietary strategies that target a patient's needs.[127] This research may help in the development of personalized diabetes management protocols.[128]

Cardiovascular and mortality outcomes must be studied longitudinally to evaluate the benefits of traditional diets compared to those promoted by conventional diabetes care.[129] To allow different ethnic and cultural cross-generalizations, diverse population samples must be included in these studies.[130] Health economics research can answer questions regarding direct medical costs and indirect benefits such as enhanced quality of life and reduced healthcare complications due to chronic illness, thereby aiding healthcare policymakers in making decisions about integrated care coverage.[131] This type of research is crucial for informing policy decisions on integrated care coverage.[132]

7.3. Technology integration opportunities

The integration of new technologies can improve the effectiveness of holistic dietary interventions and monitoring. Artificial intelligence software could be used to evaluate traditional constitutional methods in combination with modern biomarkers to provide bespoke dietary recommendations.[133] This could improve the accessibility of traditional evaluation methods in modern healthcare systems.[134] Mobile health applications offer live seasonal dietary guidance, modification of existing recipes, and cooking style instructions tailored to a user's health profile and preferences.[135] Such tools could enhance patient empowerment while also creating the potential for long-term behavioral changes.[136]

Fig. 8. Future research direction in traditional Chinese diets in diabetes management.
Notes: AI: artificial intelligence.

Through the integration of traditional dietary approaches with genetics, microbiome, and continuous glucose monitoring analyses, precision nutrition platforms can provide personalized meal planning and timing schedules.[137] This approach can strengthen the optimization of conventional and holistic therapeutic approaches.[138] CM practitioners can collaborate with conventional healthcare providers through telemedicine platforms, thereby enabling geographically agnostic, comprehensive, and integrated care.[139] These tools can broaden the range of integrated care for diverse patient populations.[140] Fig. 8 shows future research directions in traditional Chinese diets for diabetes management.

8. Conclusion

This narrative review highlights the strong alignment between CM and modern nutritional science in the use of regional Chinese cuisines for diabetes management. Ancient food therapy principles correspond with contemporary insights into bioactive compounds, gut microbiota, and metabolic health, supporting integrative and evidence-based approaches. Each of the five regional cuisines offers distinct therapeutic benefits: capsaicin and sanshool in Sichuan enhance insulin sensitivity; Cantonese cuisine retains nutrients through fresh preparation; Shandong cooking improves protein quality and balance; Hunan fermented foods support gut health; and Jiangsu emphasizes seasonal nutrient-dense ingredients.

The integration of traditional and modern methods provides a comprehensive strategy for managing the complex nature of diabetes. Traditional assessments such as constitutional typing can enhance personalized western dietary plans, while biomedical insights can enhance the therapeutic application of traditional foods. Integrated approaches have demonstrated improved glucose control, reduced medication reliance, and an enhanced quality of life. Mechanisms, such as improved glucose transport, insulin sensitivity, and gut microbiota modulation suggest that these strategies target root causes and not only symptoms. To advance integrated care, future research should prioritize mechanistic studies, large-scale trials, and technology-enabled personalization, such as combining traditional diagnostics with modern biomarkers. It is the appropriate time for health systems to adopt this integrated model. Fusing scientific rigor with traditional wisdom offers sustainable and culturally relevant strategies for treating diabetes, meeting urgent health challenges with holistic innovation.

CRediT authorship contribution statement

Enoch Chi Ngai Lim Conceptualization, data curation, methodology, formal analysis, investigation, visualization, writing – original draft, and writing – review & editing. **Xue Fei Yu**: Validation, visualization, and writing – review & editing. **Chi Eung Danforn Lim**: Conceptualization, resources, formal analysis, investigation, supervision, validation, visualization, and writing – review & editing.

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Declaration of competing interest

The authors declare that there are no conflicts of interest.

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