

Dietary Patterns in the Prevention and Management of Chronic Kidney Disease: A Mini Review

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ABSTRACT

Chronic kidney disease (CKD) is closely linked to diet-related non-communicable diseases, particularly diabetes mellitus and hypertension. Appropriate nutritional management plays a critical role in both prevention and progression of CKD. Conventional nutrition interventions for CKD have focused on a single-nutrient approach, but there is a growing shift toward evaluating overall dietary patterns and their synergistic effects on health outcomes. This review examines their influence on CKD risk and progression. Evidence suggests that dietary patterns such as the Mediterranean, Dietary Approach to Stop Hypertension (DASH), plant-based, and low-protein diets may confer benefits in CKD prevention and management, although individual modifications and close monitoring are necessary. Ketogenic diets may provide metabolic benefits in some populations, but their role in CKD remains uncertain due to potential renal concerns and limited long-term evidence. In contrast, Western dietary patterns, characterized by high intakes of processed foods, red and processed meat, refined carbohydrates, and added sugars, are generally associated with less favourable kidney outcomes. Overall, dietary advice should emphasize a variety of whole and minimally processed foods, including fruits, vegetables, whole grains, plant-based proteins, and healthy fats, while limiting highly processed and ultra-processed foods and excessive intakes of sodium, fat, and sugar. A shift from isolated nutrient restrictions toward practical, food- and pattern-based recommendations may improve the feasibility and sustainability of dietary management. In conclusion, dietary intervention for CKD should be individualized, culturally appropriate, feasible, and supported by regular nutritional assessment and monitoring by healthcare professionals.

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1. Introduction

Chronic kidney disease (CKD) represents a substantial global health burden, affecting over 788 million individuals worldwide according to the Global Burden of Disease Study 2023 (Collaborators, 2025). In Malaysia, the prevalence of CKD has increased markedly, rising from 9.07% to 15.48% in 2018 in seven years (Saminathan *et al.*, 2020). Diet-related non-communicable diseases, particularly diabetes mellitus and hypertension, remain the key causes of CKD in the Malaysian population (Saminathan *et al.*, 2020). Nutritional management is crucial in maintaining kidney function, preventing complications, and slowing

progression to end-stage kidney disease. The Kidney Disease: Improving Global Outcomes (KDIGO) guidelines serve as a primary reference for dietary management, advocating individualized nutrition care tailored to patients' age, disease stage, and comorbid conditions (Kidney Disease: Improving Global Outcomes, 2024). Current dietary guidelines emphasize sodium reduction, controlled protein intake, and restriction of potassium and phosphorus to mitigate further renal damage.

Despite the established importance of dietary management, adherence to dietary recommendations remains suboptimal across CKD populations (Vr & Kaur Kang, 2022). Individuals with advanced CKD have been shown to exhibit particularly low adherence, with poorer overall diet quality and insufficient intake of whole grains, dairy, and soy-based foods (Ouyang *et al.*, 2025). In non-dialysis patients, haemodialysis and peritoneal dialysis patients, as well as kidney transplant recipients, the key barrier to adherence was the perceived burden of dietary restrictions (Trigueros-Flores *et al.*, 2025). Moreover, nutrient-specific recommendations may require patients to simultaneously monitor and restrict multiple nutrients, which can make dietary advice complex and difficult to translate into everyday food choices. Focusing primarily on individual nutrients may also overlook the interactions between foods and nutrients within the overall diet. Given these challenges, there is a need for dietary guidance that considers the overall composition of the diet and is more practical and accessible for individuals with CKD.

Beyond individual nutrient restrictions, emerging evidence indicates that overall dietary patterns are significant in the prevention and progression of CKD. Dietary patterns refer to the combination, variety, quantity, and frequency of foods and beverages consumed habitually, reflecting how foods are consumed together within the overall diet. This approach provides a broader perspective than focusing on individual nutrients and may better capture the complex interactions between foods, nutrients, and dietary components. Healthy dietary patterns may reduce the risk of CKD, whereas Western-style diets are linked to increased risk (He *et al.*, 2021). Specifically, higher consumption of healthy food including vegetables, fruits, and whole grains, alongside lower consumption of red and high-fat meats, appears protective against CKD development (He *et al.*, 2021). Over recent years, the role of established dietary patterns such as Mediterranean diet, the Dietary Approaches to Stop Hypertension (DASH) diet, and plant-based diet in CKD management has attracted increasing attention.

Although several reviews have examined the relationship between diet and CKD, the evidence remains heterogeneous, with differences in the dietary patterns investigated, populations studied, disease stages, and outcomes assessed. In addition, dietary patterns continue to evolve as evidence regarding food-based approaches to CKD prevention and management expands. A synthesis of the current evidence is therefore needed to clarify the potential role of different dietary patterns across CKD outcomes and to identify areas where evidence remains limited. This mini-review aims to examine the current evidence on how different dietary patterns influence the risk and progression of CKD, with the goal of informing more practical and patient-centred dietary strategies.

2. Key Nutrients in CKD Nutritional Management

2.1 Energy intake

Adequate energy intake is essential in CKD management to maintain nutritional status and prevent protein-energy wasting. Inadequate energy intake may cause the body to use dietary and body proteins for energy, increasing the risk of muscle loss and malnutrition, particularly when protein intake is restricted. This is especially important in CKD, where inflammation, comorbidities, poor appetite, and dietary restrictions may further reduce energy intake. An energy intake below 25 kcal/kg/day has been associated with a higher risk of protein-energy wasting, muscle loss, and functional decline (Liu *et al.*, 2024). Therefore, adequate energy intake is an important part of nutritional management. The KDOQI guidelines recommend an energy intake of approximately 25–35 kcal/kg body weight per day for metabolically stable adults with CKD (Kidney Disease: Improving Global Outcomes, 2024). The requirements should be individualized according to age, sex, physical activity, body composition, weight goals, CKD stage, and the presence of inflammation or other illnesses. Energy intake should therefore be managed to maintain nutritional status while avoiding excessive energy intake that may contribute to obesity and related metabolic complications.

2.2 Protein

Protein restriction is important in CKD management because impaired kidney function reduces the clearance of nitrogenous waste from protein breakdown. Excessive protein intake may increase kidney workload, uremic toxin production, and glomerular hyperfiltration through afferent arteriolar vasodilation. In contrast, protein restriction can reduce intraglomerular pressure and hyperfiltration, similar to the action of sodium-glucose cotransporter 2 inhibitors (Jamale & Bose, 2024). Current guidelines recommend individualized protein intake according to CKD stage and risk of progression. For adults with CKD stage 3 to 5, KDIGO recommends approximately 0.8 g/kg/day and avoiding intake above 1.3 g/kg/day in those at risk of CKD progression (Kidney Disease: Improving Global Outcomes, 2024). A very low-protein diet of 0.3–0.4 g/kg/day, supplemented with essential amino acids or ketoacid analogues up to 0.6 g/kg/day, may also be considered under close supervision (Kidney Disease: Improving Global Outcomes, 2024). In addition to protein quantity, protein sources may also affect CKD outcomes. Higher intake of animal protein, particularly red and processed meat, may increase dietary acid load and uremic toxin production, whereas plant-based protein provides fibre and other beneficial components that may support gut and metabolic health (Freeman & Turner, 2024). However, evidence comparing protein sources remains mixed. Therefore, CKD dietary management should consider both protein quantity and source, with appropriate inclusion of plant-based protein according to individual nutritional needs and potassium and phosphorus levels.

2.3 Sodium

Hypertension is both a major cause and common comorbidity of CKD, significantly contributing to disease progression and cardiovascular risk. Reducing dietary sodium may lower systolic and diastolic blood pressure. However, impaired renal function may affect sodium excretion and cause fluid retention. This increases blood volume and elevates blood pressure. These changes highlight the importance of sodium management in CKD care. Current guidelines recommend limiting sodium intake to less than 2 g per day (approximately <5 g sodium chloride/day) for individuals with CKD (Kidney Disease: Improving Global Outcomes, 2024). Adherence to sodium intake recommendation helps reduce fluid overload, control blood pressure, and potentially slow CKD progression. In addition to its effects on blood pressure, sodium restriction may reduce proteinuria by decreasing extracellular fluid volume and intraglomerular pressure. High sodium intake can increase renal perfusion and intraglomerular pressure, promoting greater leakage of albumin across the glomerular filtration barrier and consequently increasing urinary protein excretion. Furthermore, sodium restriction enhances the antihypertensive and antiproteinuric effects of angiotensin receptor blockers, further contributing to renal protection (Lambers Heerspink *et al.*, 2012).

2.4 Potassium

CKD is associated with impaired potassium excretion and an increased risk of hyperkalemia, a potentially life-threatening condition linked to cardiac arrhythmia and adverse outcomes. Evidence on potassium intake across CKD stages is inconsistent: higher intake in early CKD may be protective, whereas in advanced CKD, associations remain inconclusive, requiring individualized assessment and monitoring (Picard *et al.*, 2020). Potassium bioavailability differs by source, with plant-based foods absorbed at 50%–60%, animal-based foods at 70%–90%, and processed foods with additives at around 90% (Kidney Disease: Improving Global Outcomes, 2024). Importantly, routine or unnecessary potassium restriction may compromise dietary quality by limiting fruits and vegetables, which provide fibre, vitamins, minerals, and bioactive compounds that support overall health. Although traditionally restricted because of their potassium content, plant-based diets may improve gut dysbiosis, reduce protein-fermenting species and uremic toxin production, and enhance intestinal motility and short-chain fatty acid production through higher fibre intake. Fruit and vegetable consumption may also reduce dietary acid load and metabolic acidosis, while lower phosphorus bioavailability from plant foods may help reduce hyperphosphatemia. Their magnesium and vitamin K content may prevent deficiencies, while reduced inflammation and oxidative stress may contribute to slower

CKD progression and fewer complications (Cases *et al.*, 2019). Although hyperkalemia remains a concern, appropriate cooking techniques can reduce potassium absorption. Therefore, potassium management should be individualized according to serum potassium, CKD stage, medications, and dietary pattern, with restriction applied only when clinically indicated while preserving dietary quality and nutritional adequacy.

2.5 Phosphorus

Hyperphosphatemia or elevated serum phosphorus may occur due to the impaired ability to excrete phosphorus when the kidney function declines. Hyperphosphatemia reduces bone mineral density and increases fracture risk, while promoting vascular calcification and calcium deposition in blood vessels, thereby increasing cardiovascular morbidity and mortality. Dietary phosphorus exists as organic and inorganic forms. Organic phosphorus is found naturally in protein-rich foods, including meat, poultry, fish, nuts, legumes, and dairy products, with absorption varying according to the food source. Phosphorus from plant foods is generally less bioavailable because much of it is bound to phytate, which is poorly digested by humans, whereas phosphorus from animal foods is more readily absorbed. In contrast, inorganic phosphorus salts used as food additives and preservatives are highly bioavailable and can be absorbed at a substantially higher rate, approaching 100% (Office of Dietary Supplements, 2023). Therefore, the presence of phosphorus additives in processed and ultra-processed foods may contribute disproportionately to phosphorus exposure compared with naturally occurring phosphorus. Given these differences in bioavailability, limiting foods containing phosphorus additives may be a more targeted strategy for reducing dietary phosphorus burden. Patients with CKD are therefore advised to minimize processed and ultra-processed foods while moderating intake of naturally phosphorus-rich foods. Such approaches are essential to control serum phosphorus levels, protect bone health, and reduce the risk of cardiovascular complications (National Kidney Foundation, 2024).

3. Major dietary patterns and CKD

There is increasing evidence that support the role of overall dietary patterns, rather than single nutrients, in affecting CKD risk and progression. Six commonly studied dietary patterns can be broadly classified based on their associations with renal outcomes (**Figure 1**). The Mediterranean, DASH, plant-based, and low-protein diets are generally considered renoprotective, whereas the Western and ketogenic dietary patterns have been associated to less favourable renal and cardiometabolic outcomes. Selected studies on the relationship between various dietary patterns and the risk or progression of kidney disease were also presented in **Table 1**. The following sections provide an overview of each dietary pattern and their potential effects for kidney health.

Dietary Patterns and Renal Outcome in CKD

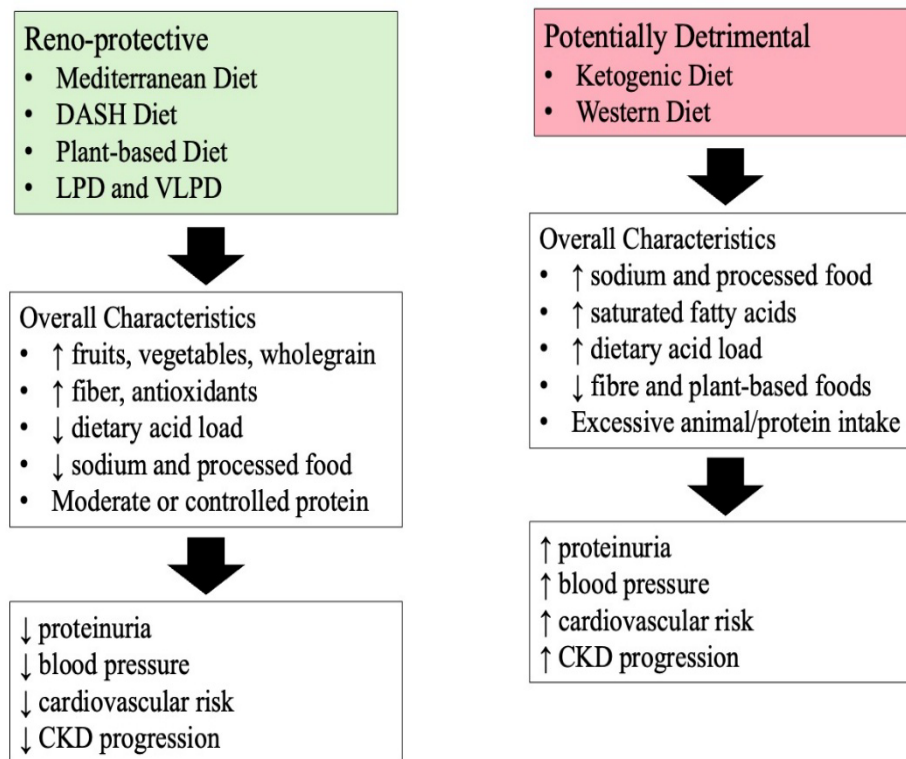


Figure 1. Overview of dietary patterns and their associations with renal outcomes in CKD.

Renoprotective dietary patterns, including the Mediterranean, DASH, plant-based, and low-protein diets, are characterized by higher intake of fruits, vegetables, whole grains, and fibre, along with lower dietary acid load, sodium, and processed food consumption, contributing to reduced proteinuria, blood pressure, cardiovascular risk, and CKD progression. In contrast, potentially detrimental dietary patterns, such as the Western and ketogenic diets, are characterized by higher intake of sodium, saturated fats, and animal-based or processed foods, with lower fibre intake, leading to increased proteinuria, blood pressure, cardiovascular risk, and accelerated CKD progression. Abbreviations: CKD, chronic kidney disease; DASH, dietary approach to stop hypertension; LPD, low protein diet; VLPD, very low protein diet.

Table 1: Selected studies on the association between various dietary patterns and kidney outcomes.

Dietary patterns	Author, year	Study design	Country	N	Population	Findings
Mediterranean diet	Maroto-Rodriguez <i>et al.</i> , 2025	Prospective cohort study	United Kingdom	106870	General population aged 40-70	Higher adherence to Mediterranean diet had lower risk of chronic kidney disease. HR (95% CI) = 0.84 (0.76, 0.93), $p=0.001$
	Bayan-Bravo <i>et al.</i> , 2022	Prospective cohort study	Spain	975	General population aged 60 and older	Higher adherence to Mediterranean diet had lower risk of CKD. OR (95% CI) = 0.52 (0.29, 0.95), $p=0.015$
	Kwon <i>et al.</i> , 2024	Randomized crossover trial	Korea	46	Patients aged 20 years and older, stage 3-4 CKD (pre-dialysis)	Patients following the Mediterranean diet had a higher post-intervention eGFR values than following the control diet. eGFR (95%CI) = -3.19 (-5.60, -0.78), $p=0.011$ No significant difference in protein, creatinine, protein/creatinine ratio, sodium, potassium, and albumin in urine analysis.
DASH diet	Giulia <i>et al.</i> , 2026	Prospective cohort study	Sweden	27126	Healthy adult population	Higher adherence to DASH diet had lower risk of CKD (in females). HR (95%CI) = 0.70 (0.54, 0.91), $p=0.007$
	Maroto-Rodriguez <i>et al.</i> , 2025	Prospective cohort study	United Kingdom	106870	General population aged 40-70	Higher adherence to DASH diet had lower risk of CKD. HR (95% CI) = 0.77 (0.70, 0.85), $p < 0.001$.
	Rebholz <i>et al.</i> , 2016	Prospective cohort study	United States	3720	General population aged 45-64	Lower adherence to DASH diet had higher risk of CKD. HR (95%CI) = 1.16 (1.07-1.26), $p < 0.001$
Plant-based diet	Amir <i>et al.</i> , 2025	Prospective cohort study	United States	2539	Adults aged 21 to 74 years with mild to moderate CKD (eGFR of 20 to 70 mL/min per 1.73 m ²)	Higher adherence to plant-based diets reduced the risks of all-cause mortality. HR (95%CI) = 0.74 (0.62, 0.88), $p < 0.001$ Higher adherence to healthy plant-based diets reduced the risks of all-cause mortality HR (95%CI) = 0.79 (0.66, 0.95), $p=0.03$ Each 10-point higher score of unhealthy

Dietary patterns	Author, year	Study design	Country	N	Population	Findings
Low protein or very low protein diet						plant-based diets was associated with a higher risk of CKD progression [HR (95%CI) = 1.14 (1.03, 1.25)] and all-cause mortality [HR (95% CI) = 1.11 (1.00, 1.23)].
	Thompson <i>et al.</i> , 2024	Prospective cohort study	United Kingdom	4807	Adults with CKD	Higher adherence to healthful plant-based diet had a lower risk of mortality. HR (95% CI) = 0.66 (0.52, 0.83), $p < 0.001$. Higher adherence to unhealthful plant-based diet had a higher risk of mortality. HR (95%CI) = 1.52 (1.20, 1.93), $p = 0.002$. Each 0.1g/kg daily higher baseline urea excretion-based dietary protein intake was associated with end-stage kidney disease. HR (95%CI) = 1.05 (1.01, 1.10). Each 0.1g/kg daily higher baseline food record-based dietary protein intake was associated with end-stage kidney disease. HR (95%CI) = 1.09 (1.04, 1.14). Patient following low protein diet had a slower decline in estimated glomerular filtration rate compared with those who were not on low protein diet (-0.89 versus -2.65 ml/min/1.73 m ² /year), with an 84% reduction in the need for kidney replacement therapy [HR (95% CI) = 0.16 (0.07, 0.39)], 78% in all-cause mortality [HR (95%CI) = 0.22 (0.06, 0.72)] and 81% in the composite outcome death or dialysis [HR (95%CI) = 0.19 (0.09, 0.38)].
	Metzger <i>et al.</i> , 2018	Prospective cohort study	France	920	Adult patients aged over 18 with all stages of CKD and any type of kidney disorder	
	Vischini <i>et al.</i> , 2026	Retrospective cohort study	Italy	182	Patients with advanced CKD (stage 4–5)	
Ketogenic diet (Low carbohydrate, high protein and high fat)	Zhang & Dong, 2025	Cross-sectional study	United States	701	Women with history of gestational diabetes mellitus	Participants with a high low carbohydrate diet score (consumption of more protein and fat and less carbohydrate) were more likely to have CKD (adjusted OR (95%CI) = 3.40 (1.73-6.70), $p < 0.001$)

Dietary patterns diet)	Author, year	Study design	Country	N	Population	Findings
	Lin <i>et al.</i> , 2010	Cross-sectional study	United States	3348	Adults aged between 30 to 55 years	Higher intakes of saturated fat (adjusted OR (95%CI) = 1.62 (1.02, 2.59) and animal fat (adjusted OR (95%CI) = 1.49 (1.08, 2.07) were significantly associated with increased odds of eGFR decline of more than 30%.
Western diet	Xu <i>et al.</i> , 2019	Cross-sectional study	China	2437	Adults aged between 45 to 59 years	Participants in the highest quartile of the Western dietary pattern had greater odds of CKD. OR (95%CI) = 1.83 (1.21, 2.81), $p < 0.05$.
	Asghari <i>et al.</i> , 2018	Prospective cohort study	Iran	1630	Adults > 27 years without a history of CKD at baseline	Participants with high fat, high sugar dietary pattern (resembling a Western dietary pattern) had greater odds of CKD. OR (95%CI) = 1.46 (1.03, 2.09), $p = 0.036$.

Abbreviation: HR, hazard ratio; CI, confidence interval; OR, odd ratio; CKD, chronic kidney disease; eGFR, estimated glomerular filtration rate; DASH, dietary approach to stop hypertension.

3.1 Mediterranean Diet

The Mediterranean dietary pattern is characterized by a high consumption of fruits, vegetables, whole grains, potatoes, legumes, nuts, and seeds, with olive oil serving as the principal source of fat. It includes moderate amounts of dairy products, eggs, fish, and poultry, while limiting red meat and highly processed foods (Health, 2023). This dietary pattern emphasizes minimally processed, nutrient-dense foods, which provide high intakes of dietary fibre, antioxidants, and healthy fats.

Accumulating evidence indicates that adherence to the Mediterranean diet confers protective effects against the incidence and progression of CKD (Bayan-Bravo *et al.*, 2022; Maroto-Rodriguez *et al.*, 2025). Sustained adherence has also been linked to improved management and prevention of various chronic diseases, including diabetes mellitus, obesity, cancer, and CKD, as well as enhanced overall quality of life (Godos *et al.*, 2025). In relation to kidney health, this dietary pattern has been associated with reduced CKD risk (Maroto-Rodriguez *et al.*, 2025) and a lower likelihood of disease progression (Bayan-Bravo *et al.*, 2022).

Several mechanisms may contribute to these potential renal benefits. First, the anti-inflammatory properties of the Mediterranean diet may help attenuate chronic low-grade inflammation, which is implicated in CKD development and progression. Its high intake of fruits, vegetables, whole grains, nuts, and olive oil provides fibre, polyphenols, and unsaturated fatty acids that may help modulate inflammatory pathways. Second, its high content of antioxidant-rich foods may reduce oxidative stress, which contributes to renal cellular injury and CKD progression. Third, the high fibre content may promote a more favourable gut microbiota composition and reduce the production of gut-derived uremic toxins, while potentially lowering systemic inflammation (Caldioli *et al.*, 2022; Wakino *et al.*, 2025). Finally, the greater consumption of plant-based foods may reduce dietary acid load and help improve metabolic acidosis, while the emphasis on minimally processed foods may also contribute to lower sodium intake (Kwon *et al.*, 2024). These mechanisms may act synergistically to support kidney health.

Moreover, the global burden of CKD attributable to insufficient whole grain intake remains high and continues to rise (Zhao *et al.*, 2026). Increased consumption of whole grains has been associated with a lower risk of CKD (Xu *et al.*, 2024), representing a central component of the Mediterranean diet. Additionally, a “green” Mediterranean variant, which places greater emphasis on plant-based foods and further limits animal-derived products, may confer additional advantages for individuals with CKD (Oikonomaki, 2025). Overall, the Mediterranean diet, with its emphasis on plant-based, minimally processed foods and its adaptability across cultural contexts, represents a promising approach for both the prevention and management of CKD (Salomone *et al.*, 2026).

3.2 Dietary Approaches to Stop Hypertension (DASH) Diet

The DASH dietary pattern promotes a high intake of vegetables, fruits, and whole grains, alongside fat-free or low-fat dairy products, fish, poultry, legumes, nuts, and plant-based oils, while restricting foods rich in saturated fats such as fatty meats, full-fat dairy, and tropical oils (e.g., coconut and palm-derived oils). It also encourages limiting sugar-sweetened beverages and added sugars (NHLBI, 2026).

This dietary approach is typically low in sodium and relatively rich in potassium, magnesium, and calcium, which contribute to blood pressure control and may offer indirect benefits for kidney health. Evidence from systematic reviews and meta-analyses consistently indicates that greater adherence to the DASH diet is associated with a reduced risk of hypertension compared with lower adherence (Guo *et al.*, 2021; Mu *et al.*, 2022; Theodoridis *et al.*, 2023).

Adherence to the DASH dietary pattern has also been linked to a lower risk of CKD (Giulia, 2026; Maroto-Rodriguez *et al.*, 2025; Rebholz *et al.*, 2016), although evidence on slowing CKD progression remains limited (Aderoju *et al.*, 2025). Modified versions of the DASH diet applied in East Asian populations have demonstrated benefits in reducing the risk of type 2 diabetes, metabolic syndrome, and CKD (Song *et al.*, 2021). Although the relatively high potassium content of the DASH diet may require consideration in individuals with advanced CKD or a high risk of hyperkalaemia, modified DASH approaches can remain appropriate when potassium intake is individualized and monitored according to kidney function and serum

potassium levels. Therefore, DASH should not be considered unsuitable for CKD generally, but should be appropriately adapted and monitored according to individual clinical needs.

3.3 Plant-Based Diets

Plant-based dietary patterns include vegan diets, which exclude all animal-derived products, and vegetarian diets, which may include selected animal foods. Vegetarian diets can be further classified as lacto-vegetarian (dairy), ovo-vegetarian (eggs), and lacto-ovo vegetarian (dairy and eggs). These patterns emphasize fruits, vegetables, whole grains, legumes, nuts, and seeds, with limited or no red meat, and may benefit individuals with CKD through greater reliance on plant protein. Beyond protein quantity, protein source is increasingly recognized as important. Plant-based diets are associated with lower dietary acid load, higher fibre intake, and potential cardiovascular and survival benefits (Freeman & Turner, 2024). Although plant foods generally contain potassium and phosphorus, these minerals often have lower bioavailability than those from animal sources, particularly phosphorus because much plant phosphorus is bound to phytate. However, lower bioavailability does not eliminate the risk of hyperkalaemia or hyperphosphataemia in susceptible individuals with impaired renal function. Thus, potassium and phosphorus intake should be considered based on CKD stage, kidney function, laboratory findings, and the overall dietary pattern.

Greater adherence to plant-based dietary patterns has been associated with lower CKD risk and slower disease progression (Dang *et al.*, 2025). However, diet quality remains important. Healthy plant-based diets rich in fruits, vegetables, whole grains, legumes, nuts, and seeds are associated with lower CKD risk and mortality (Amir *et al.*, 2024; Maroto-Rodriguez *et al.*, 2025; Thompson *et al.*, 2024). In contrast, unhealthy plant-based diets high in refined grains, added sugars, and processed foods are associated with higher CKD risk, faster progression, and mortality (Amir *et al.*, 2024; Thompson *et al.*, 2024). Protein quality should also be considered as many plant proteins have lower digestibility and less favourable essential amino acid profiles than animal proteins. Measures such as Protein Digestibility-Corrected Amino Acid Score (PDCAAS) and Digestible Indispensable Amino Acid Score (DIAAS) assess protein quality based on amino acid composition and digestibility. However, combining different plant protein sources can improve the overall amino acid profile. Careful planning is therefore needed to meet protein requirements while retaining the benefits of plant-based diets.

Individualisation remains essential to ensure adequate essential amino acids and reduce the risk of protein–energy wasting, sarcopenia, and muscle loss, particularly in older adults and those with advanced CKD. Suitability should therefore be determined by CKD stage, nutritional status, comorbidities, biochemical parameters, protein requirements, and overall dietary quality.

3.4 Low-Protein and Very Low-Protein Diets

Low-protein diets are commonly prescribed to limit the accumulation of nitrogenous waste products, reduce uremic symptoms, and slow disease progression. Research indicates that patients who adhere to such diets experience a more gradual decline in kidney function, reflected by a significantly smaller annual decrease in estimated glomerular filtration rate compared with those who do not adhere (Brum *et al.*, 2025; Metzger *et al.*, 2018; Vischini *et al.*, 2026). However, the role of dietary protein restriction in contemporary CKD management remains debated, as advances in pharmacological therapies, including renin–angiotensin–aldosterone system (RAAS) inhibitors, sodium–glucose cotransporter-2 (SGLT2) inhibitors, and glucagon-like peptide-1 (GLP-1) receptor agonists, have substantially improved kidney and cardiovascular outcomes. Some experts therefore argue that the incremental benefit of strict protein restriction may be less important when these evidence-based therapies are appropriately implemented, highlighting the need to consider dietary and pharmacological management together.

Despite their benefits, these dietary approaches require careful supervision to prevent negative nutritional outcomes, including protein–energy wasting and disturbances in mineral and bone metabolism, particularly if protein intake is excessively restricted or dietary intake is inadequate (Pereira *et al.*, 2024). Special consideration is needed for very low-protein diets, especially in plant-based dietary patterns. At an

intake of 0.6 g/kg/day, conventional low-protein diets are generally more capable of meeting essential amino acid needs, whereas plant-based versions at this level may fall short; adequacy is more likely achieved at intakes of ≥ 0.7 g/kg/day. Moreover, plant-based low-protein diets are typically richer in potassium, phosphorus, and calcium, yet lower in long-chain omega-3 fatty acids and vitamin B12, with potential micronutrient gaps observed in both plant- and animal-derived low-protein regimens (Khor *et al.*, 2021).

Overall, while low-protein diets can slow down the progress of CKD and reduce metabolic burden, achieving and maintaining dietary adherence remains a significant challenge. Ensuring adequate energy intake and preventing protein-energy wasting requires individualized planning, regular monitoring of nutritional status, and ongoing dietary intervention. The involvement of a trained dietitian is therefore essential, although this may be a challenge in low-resource settings.

3.5 Ketogenic Diets

Ketogenic diets have gained attention for weight management and metabolic health and are typically characterized by very low carbohydrate, high fat, and moderate-to-high protein intake, depending on the formulation. Potential benefits include weight loss and improved insulin resistance and glycaemic control, which may be relevant to CKD prevention given the links between obesity, diabetes, and CKD. Ketogenic diets may therefore help reduce obesity-related CKD risk and may be more suitable for prevention or early-stage CKD, although evidence on long-term safety remains limited (D'Alessandro *et al.*, 2025). Studies in individuals with type 2 diabetes suggest that ketogenic diets may improve some metabolic outcomes, including triglycerides and high-density lipoprotein cholesterol, although effects on glycaemic control are inconsistent (Choy & Louie, 2023; Yuan *et al.*, 2020). However, these findings cannot be directly applied to people with CKD.

Potential concerns include increased renal workload, nephrolithiasis, metabolic acidosis, and glomerular hyperfiltration, particularly when diets are high in protein or animal-derived foods. Higher protein and fat intake with lower carbohydrate intake has been associated with increased CKD risk (Zhang & Dong, 2025), while higher intakes of saturated and animal fats have been associated with greater odds of an eGFR decline of more than 30% (Xu *et al.*, 2020). High saturated fat intake may also increase cardiovascular risk, while low fruit and vegetable intake may reduce dietary alkali and increase the risk of metabolic acidosis (Joshi *et al.*, 2024). Nephrolithiasis is another potential concern, although risk may vary by dietary composition and individual characteristics.

Overall, evidence on ketogenic diets in CKD remains limited, particularly regarding renal outcomes and long-term safety. Further well-designed CKD studies are needed before routine use can be recommended. Where used, kidney function, dietary composition, acid-base status, lipid profile, and other relevant clinical parameters should be monitored.

3.6 Western Diet and Ultra-processed Food

Western diets are typically marked by high intake of red and processed meats, sugar-sweetened beverages, refined carbohydrates, sodium, saturated fats, and ultra-processed foods, together with insufficient consumption of fruits, vegetables, and whole grains. Such diets have been consistently associated with higher risk of chronic diseases including CKD, with underlying mechanisms likely involving systemic inflammation and oxidative stress (Clemente-Suarez *et al.*, 2023). High intake of red and processed meats has also been associated with unfavourable renal outcomes, including microalbuminuria, severe albuminuria, and increased blood urea nitrogen levels (Dai & Guo, 2025; Mirzababaei *et al.*, 2024). Similarly, frequent consumption of sugar-sweetened beverages may contribute to the burden of CKD (Yin *et al.*, 2024). The high saturated fat content commonly observed in Western dietary patterns may further promote renal injury through oxidative stress, inflammation, endoplasmic reticulum stress, and mitochondrial dysfunction (Sanchez-Navarro *et al.*, 2021; Wypych, 2023). Overall, Western dietary patterns are generally considered unfavourable for CKD prevention and management due to their high intake of foods and nutrients associated with adverse renal outcomes.

Ultra-processed foods warrant separate consideration because their consumption is not limited to Western dietary patterns. Greater intake of ultra-processed foods has been associated with an increased risk of CKD in the general population (Asghari *et al.*, 2018; Du *et al.*, 2022; Leonberg *et al.*, 2025; Xu *et al.*, 2020), as well as disease progression and higher all-cause mortality among individuals with established CKD (Sullivan *et al.*, 2023). Ultra-processed foods are often energy-dense and may contain high levels of sodium, added sugars, and saturated fats, while providing fewer beneficial nutrients. Their potential adverse effects on kidney health may therefore involve multiple pathways, including poor overall nutrient profiles, metabolic disturbances, inflammation, and oxidative stress. Importantly, the relationship between ultra-processed food intake and CKD may extend beyond the broader concept of a Western dietary pattern, supporting the consideration of ultra-processed food consumption as an independent dietary characteristic when evaluating kidney health.

4. Individualized Nutrition and Cultural Considerations in CKD

For CKD prevention, reducing major risk factors such as diabetes mellitus, hypertension, and obesity is essential. Dietary patterns such as the Mediterranean, DASH, plant-based, and ketogenic diets may help reduce these risks. Overall, prevention should promote diets rich in fruits, vegetables, whole grains, and healthy fats, while limiting sodium, red and processed meats, sugar-sweetened beverages, and ultra-processed foods. In early CKD, some dietary patterns may provide benefits, but not all fully align with KDIGO recommendations for moderate protein intake, sodium restriction, and appropriate potassium and phosphorus intake. Therefore, close monitoring is needed to slow disease progression and manage comorbidities. In advanced CKD, greater dietary modification may be required to reduce complications and delay kidney failure and dialysis. Although monitoring individual nutrients remains important, excessive dietary restrictions may reduce adherence. Thus, focusing on overall dietary patterns may be more practical and sustainable. Patient-centred and accessible nutrition education is particularly important for populations with lower health literacy in Malaysia (Ho *et al.*, 2025). Mediterranean, DASH, plant-based, low-protein, and ketogenic diets should therefore be appropriately modified and monitored according to individual needs.

The feasibility of dietary modification is also influenced by culture, food accessibility, affordability, and health policies. Food prices, availability of healthier options, nutrition policies, and subsidies can shape food choices and protein sources. In Malaysia, common protein sources include chicken, fish, eggs, dairy products, legumes, tofu, and tempeh, although their intake varies across ethnic and religious groups (Drewnowski *et al.*, 2020). Policies that improve access to affordable, healthier foods, including minimally processed plant proteins, may support adherence to CKD dietary recommendations.

Cultural and regional practices should therefore be considered when developing dietary recommendations (Oquendo *et al.*, 2017). In Malaysia, sodium may come from processed foods, condiments, seasoning powders, salted fish, and fermented products. Familiar foods can be modified rather than excluded. For example, *nasi lemak* can contain smaller portions of sambal, salted peanuts, salted fish, and anchovies, while *char kway teow* can be prepared with less seasoning and oil and more vegetables. Such culturally appropriate modifications may improve adherence while maintaining familiar foods. Malaysian-specific evidence should be used where available to ensure that recommendations are relevant to local dietary practices.

5. Research Gaps and Future Directions

Despite growing interest in the role of dietary patterns in CKD, current evidence is still largely based on observational studies, with relatively few well-designed randomized controlled trials. This limits the ability to establish causal relationships and determine the long-term effectiveness and safety of specific dietary approaches across different CKD stages. Future randomized controlled trials should examine dietary patterns across different CKD stages and clinical populations, including individuals receiving dialysis, kidney

transplant recipients, and older adults, as their dietary needs, comorbidities, and nutritional risks may differ. Greater representation of Asian populations is also needed because dietary practices, food availability, and cultural preferences differ from those in Western populations. Longitudinal and intervention studies should assess not only CKD progression and clinical outcomes but also patient-centred outcomes, including quality of life, dietary adherence, and nutritional adequacy.

There is also a need to develop and evaluate culturally tailored dietary models, particularly in multiethnic countries such as Malaysia, where dietary practices are influenced by cultural, religious, and socioeconomic factors. Much of the current evidence comes from Western populations, limiting its applicability to Asian populations. Research using commonly consumed local foods and traditional dietary practices is therefore important to improve the feasibility, acceptability, and application of dietary recommendations in clinical practice. Future research should also move beyond efficacy-focused trials towards implementation science to understand how evidence-based dietary patterns can be integrated into routine CKD care. This includes identifying barriers and facilitators to dietary change and evaluating strategies that support sustained dietary changes across healthcare and community settings.

Emerging technologies may further improve the delivery and monitoring of dietary interventions. Digital nutrition counselling, mobile-based dietary support, and artificial intelligence (AI)-assisted dietary monitoring may provide personalized feedback, improve dietary self-monitoring, and support long-term adherence. Precision nutrition may also allow dietary recommendations to be tailored to individual clinical status, metabolic responses, and dietary behaviours. In addition, research on the gut microbiome may provide new insights into how dietary patterns affect gut-derived metabolites and uremic toxin production in CKD. However, the clinical relevance, effectiveness, feasibility, and safety of these approaches require further investigation.

Future research should also consider sustainability alongside kidney health and develop practical, culturally appropriate educational tools that translate dietary evidence into simple, food-based guidance. These tools should emphasize overall diet quality rather than complex dietary labels to improve understanding, adherence, and long-term implementation. Ultimately, dietary interventions should balance kidney-specific requirements with nutritional adequacy, cultural acceptability, patient preferences, and environmental sustainability.

6. Conclusion

Dietary management plays a critical role in CKD prevention and progression, with a growing shift from a single-nutrient focus toward a more holistic evaluation of overall dietary patterns. Healthy, minimally processed, and predominantly plant-based dietary patterns may be beneficial, while dietary patterns characterized by high consumption of ultra-processed foods, red meat and added sugars should be minimized. Therefore, practical food-based recommendations are warranted to translate dietary pattern evidence into actionable strategies for CKD prevention and management. In addition, these dietary strategies should be individualized, culturally appropriate, and supported by regular monitoring. Integrating these approaches into clinical practice may enhance dietary adherence and improve outcomes in CKD management.

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