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Preventing potential pitfalls of a liberalized potassium diet in the hemodialysis population

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Abstract

Emerging research suggests that a more liberalized diet, specifically a more plant-based diet resulting in liberalization of potassium intake, for people receiving hemodialysis is necessary and the benefits outweigh previously thought risks. If the prescribed hemodialysis diet is to be liberalized, the need to illuminate and prevent potential pitfalls of a liberalized potassium diet is warranted. This paper explores such topics as partial to full adherence to a liberalized diet and its consequences if any, the advantages of a high-fiber intake, the theoretical risk of anemia when consuming a more plant-dominant diet, the potential benefits against renal acid load and effect on metabolic acidosis with increased fruit and vegetable intake, the putative change in serum potassium levels, carbohydrate quality, and the healthfulness of meat substitutes. The benefits of a more plant-based diet for the hemodialysis population are multifold; however, the possible pitfalls of this type of diet must be reviewed and addressed upon meal planning in order to be avoided.

1 | INTRODUCTION

Recent advances in nutritional treatment of chronic kidney disease (CKD) suggest a more plant-based diet for optimal health of CKD patients.[1] The multiple benefits of an increased consumption of plant foods include, but are not limited to, improved gut microbiota resulting in reduced production of uremic toxins, greater anti-atherogenic effects, mitigation of metabolic acidosis,[1] and delayed progression to kidney failure requiring renal replacement therapy.[2] The benefit of a more plant-dominant diet, defined as having greater than 50% of protein sources coming from plant-based sources,[2] has been extended to those receiving renal replacement therapy as well.[1,3] When comparing the currently prescribed hemodialysis diet (low in potassium and high in protein) to a more potassium-liberalized diet (a diet that incorporates more plant-based food items but does not meet the definition of a plant-dominant diet) while maintaining the protein requirement, the nutrient profile was more favorable and included an increase in micronutrient amounts (Tables 1 and 2).[3] With the release of the newer potassium binders, the potential for a liberalized diet is more attainable than ever before even in patients at risk for hyperkalemia.

A concern is that a more plant-based diet will result in hyperkalemia as many researchers are advocating for a higher consumption of plant-based foods, which contain potassium. The assumption is that if potassium consumption from food increases, the result will be hyperkalemia. However, recent research has thoroughly discussed and demonstrated the lack of evidence that shows that the restriction of potassium-containing foods leads to better serum potassium control.[4] In fact, restricting these potassium containing foods may be more harmful to patients than beneficial.[4] In a review of case reports of orally induced hyperkalemia in those with and without kidney dysfunction, the primary causes of hyperkalemia included fruit and

TABLE 1 Comparison of a 1-day meal plan with the current recommended HD diet and a proposed liberalized HD diet

	Diets	
Meal	**Current diet**	**Liberalized diet**
Breakfast	2 scrambled eggs	2 scrambled eggs
	1 cup of coffee	1 cup of coffee
	2 slices of soft white toast	2 slices of whole wheat toast
	2 tsp of margarine	2 tbsp of butter
	2 tbsp of sugar-free maple syrup	1/2 cup of fresh strawberries
	1/2 cup of unsweetened grape juice	1/2 cup of fresh blueberries
Snack		15 grapes
		10 walnut halves
Lunch	3 oz. of grilled salmon	3 oz. of grilled salmon
	1 cup of pasta	1 cup of pasta
	1 piece of cornbread	1/2 cup of steamed broccoli
	1 tsp of margarine	Salad with tomatoes, carrots, and cucumber
	Small salad	2 tsp of olive oil
	2 tsp of olive oil	1 tsp of balsamic vinegar
	1 tsp of balsamic vinegar	
Snack	15 grapes	Baby carrots
	1/2 cup of Sprite Zero	1/4 cup of hummus
		1 medium apple
Dinner	4 oz. of steak	4 oz. of steak
	1/2 cup of mushrooms	1/2 cup of mushrooms
	1/4 cup of onion	1/4 cup of onion
	1/2 cup of boiled green beans	1/2 cup of green beans
	1/2 cup of spaghetti	1/2 baked sweet potato, w/ skin
	1 large dinner roll	1 chocolate chip cookie
	1 tsp of margarine	
	1 individual cup sugar-free Jell-O	
	1/2 cup of sugar-free lemonade	
Snack	3 cups of popcorn	3 cups of popcorn
	1 tsp of margarine	1 tsp of margarine

Source: Adapted from Sussman et al.[3]
Abbreviation: HD, hemodialysis.

vegetable consumption (kidney dysfunction only), salt substitute (both kidney dysfunction and normal kidney function), and supplement ingestion (normal kidney function only).[5] Approximately 60% of reported incidences reviewed were patients with renal dysfunction. Of the 44 incidences that were evaluated, four patients expired and three of them had normal renal function, suggesting that hyperkalemia resulting from dietary intake is only a condition in patients with renal dysfunction may be inaccurate. While the suggestion of a liberalized potassium diet, which should improve the nutrient profile for this patient population, sounds promising, it is important to preemptively discuss the potential problems that could develop with this liberalization and highlight ways these could be overcome before problems develop.

2 | PATIENT ADHERENCE

Dialysis patients have long been told to limit dietary potassium intake due to the potential risk of hyperkalemia, including the restriction of certain fruits and vegetables. The restriction of these foods, which are perceived as generally healthy, can cause confusion for the patient and lead to noncompliance or atherogenic effects.[6] Overall, diet adherence for dialysis patients is low (30–50%), and factors for lack of adherence include limited knowledge of physiology and the disease process, lack of social support, reduced perception of control, and limited understanding of the effect of following a therapeutic diet without obvious benefits.[7] A more liberalized diet would allow for less restriction to the diet, but it should be noted that a more plant-based

TABLE 2 Nutrient analysis comparison for a 1-day meal plan with the current recommended HD diet and a proposed liberalized HD diet

Nutrients		Diet: Current	Diet: Liberalized	DRI
Macronutrients	Calories (kcal)	2013	1976	
	Protein (g)	70	73.4	
	Carbohydrate (g)	229	215.3	130
	Fiber (g)	16	34.8	21–38*
	Fat (g)	91.5	97.6	ND
	Saturated fat (g)	26	28.4	
	Omega-3 (g)	1.2	2.6	1.1–1.6*
	Omega-6 (g)	13.3	14.5	11–17*
Vitamins	Vit A (μg RAE)	250.7	1847	700–900
	Vit B_1 (mg)	1.43	1.4	1.1–1.2
	Vit B_2 (mg)	1.63	1.7	1.1–1.3
	Vit B_3—NE (mg)	20	20.1	14–16
	Vit B_6 (mg)	0.7	1.4	1.3–1.7
	Vit B_{12} (μg)	1.3	1.1	2.4
	Vit C (mg)	15	135	75–90
	Vit D (μg)	2.3	2.3	15–20
	Vit E—α-tocopherol (mg)	5.3	6.06	15
	Folate (μg DFE)	531.4	480	400
	Vit K (μg)	76.3	104	90–120*
	Pantothenic acid (mg)	4.3	5.2	5*
	Biotin (μg)	32	41.06	30*
Minerals	Calcium (mg)	453.7	450	1000–1200
	Chromium (μg)	6.27	5.9	20–35*
	Copper (μg)	850	1900	900
	Fluoride (mg)	0.4	0.2	3–4*
	Iodine (μg)	59.5	56	150
	Iron (mg)	13.7	15.3	8–18
	Magnesium (mg)	170.9	233.1	310–420
	Manganese (mg)	2.4	4.7	1.8–2.3*
	Phosphorus (mg)	884.1	950.3	700
	Potassium (g)	1.5	2.8	4.7*
	Selenium (μg)	122.4	103.5	55
	Sodium (g)	2.3	2.2	1.2–1.5*
	Zinc (mg)	5.4	7.4	8–11

Source: Adapted from Sussman et al.[3]

Note: Dietary reference intake is issued by the Food and Nutrition Board of the Institute of Medicine, National Academy of Sciences, and is set for nutrient intakes of healthy people. The references above are ranges to incorporate men and women 19 years and older. They represent the recommended dietary allowances unless otherwise noted by an asterisk (*), which denotes adequate intake.

Abbreviations: DFE, dietary folate equivalents; DRI, dietary reference intake; HD, hemodialysis; ND, not determined; NE, niacin equivalents; RAE, retinol activity equivalents.

diet could be more challenging to navigate than the classic renal diet and may require more scrutiny and pre-planning. Liberalizing the restriction of plant-based potassium-rich foods may encourage dietary compliance given a greater variety of foods to consume and reducing the information burden associated with complicated food lists. Breaking the decades-long no banana–no avocado culture will require education on the patients' part, as well as the clinicians involved in their care, to ensure consistency of recommendations. Partial compliance to the proposed plant-based diet with liberalization in potassium may lead to complications including hyperkalemia.[6] Protein-energy wasting (PEW) is also a risk of partial compliance given the potential of inadequate protein intake. Therefore, close monitoring by the dietitian and physician is required in order to ensure that the liberalized diet is followed appropriately.

The approach to a new dietary pattern may be challenging for dietitians who have reinforced the dietary restrictions to their patients and may require more time to address these new liberalizations. Dietitians may be challenged by the patient as the information may seem contraindicatory to the highly restrictive traditional renal diet pattern.[7] This can be especially true if the care team recommendations are conflicting. Explanation behind the rationale of the dietary recommendations may be required in order to gain the support of the patient and to reduce the fear of consuming many plant-based foods, which may have been previously demonized.[7] Also, without clear-cut guidelines to the practice of a more plant-based approach, the dietitian may be resistant to implementing this approach. The theory of dietary potassium having a direct effect on serum potassium levels has been of much discussion over the past several years. Given the severe consequences of hyperkalemia, such as cardiac arrhythmias or cardiac arrest, dietitians may be hesitant to recommend potassium-rich plant foods.

3 | FIBER

By following a plant-based diet composed of unprocessed foods, patients will inevitably increase their fiber intake. Dietary fiber is a nondigestible, nonabsorbable carbohydrate polymer that can help facilitate potassium excretion through larger and more frequent bowel movements.[4] In one study of a patient with kidney failure, the administration of 3.5 g of psyllium twice a day led to a 32% increase in potassium excretion after 11 weeks.[8] This mechanism of elimination of potassium is especially important as colonic secretion of potassium has been shown to increase threefold, which can result in 80% of dietary potassium being secreted in the colon.[4,9] Unfortunately, too many patients on hemodialysis—up to 63%—have constipation and are unable to take advantage of this method of potassium elimination. However, it is likely that the constipation is partly from a lack of dietary fiber due to historical advice for patients with kidney disease to avoid high-fiber foods like fruits, vegetables, whole grains, nuts/seeds, and lentils/legumes, due to the theoretical concern of hyperkalemia and hyperphosphatemia. However, these risks are not supported by evidence.[10]

Fiber has also been associated with important health benefits for patients on dialysis. Recently, a prospective study ($n = 8078$) of adults on maintenance hemodialysis in Europe and South America compared fruit and vegetable intake and mortality over 2.5 years. They found that compared with lowest tertile of fruit and vegetable intake, those in the highest tertile had a lower risk of all-cause mortality (HR 0.80, 95% CI 0.71–0.91) and non-CV mortality (HR 0.77, 95% CI 0.66–0.91).[11] The reduction of mortality with increased fiber intake was also observed in a 12-year prospective cohort study of patients on peritoneal dialysis ($n = 881$). In this study, each gram per day increase in fiber intake correlated with a 13% reduction in all-cause mortality.[12]

Patients consuming higher volumes of fruits and vegetables should also be counseled to reduce their fluid intake to avoid interdialytic weight gains due to the high water content of produce. On a whole-food, plant-based diet, it is likely that the bulk of additional fiber is coming from unprocessed foods low in sodium, which may result in less fluid retention, although this would depend on the patient's baseline dietary pattern. Increased fiber intake also raises concern for weight loss due to fiber's effectiveness in reducing appetite and energy intake.[13] Although this possible phenomenon has yet to be studied in patients on dialysis, Soroka et al[14] found that patients with predialysis CKD consuming a plant-based diet had better dietary compliance and caloric intake and did not show any nutritional deficits after 6 months when compared to patients consuming an animal-protein diet.[13] Anorexia is often a complication of uremic syndrome in dialysis patients that may be reduced via increased fiber consumption to reduce uremic toxins.[15,16]

4 | ANEMIA

Patients on a plant-based diet may be at risk for developing anemia. On average, plant-based diets are lower in protein and heme iron than currently recommended dialysis diets. Dietary protein is the main precursor to hemoglobin formation, the most abundant protein within red blood cells. Wu et al. found that although the hematocrit of vegetarian patients (32.7 ± 1.0%) on hemodialysis can be maintained at a level close to that of nonvegetarian patients (32.5 ± 0.4%), erythropoietin doses were significantly higher in the vegetarian patients (4488 ± 296 vs. 5523 ± 423 U/week, nonvegetarian patients vs. vegetarian patients).[17] The need for increased EPO supplement is unclear, and more definitive research is needed on the subject.[17] Thus, due diligence must be taken to monitor and maintain adequate hematocrit levels in plant-based patients on dialysis.

Patients on dialysis, regardless of diet, are at a higher risk of iron deficiency anemia due to blood retained in the dialysis machine and tubes (up to 2 g of iron per year), frequent phlebotomies, and GI bleeding from the complications of gastritis and platelet dysfunction.[18–20] Furthermore, menstruating women may face even greater blood and iron losses. On a plant-based diet, patients have a higher intake of nonheme iron compared to heme iron. Nonheme iron exists in complexes with other digestion products when traveling through the intestines, which affects its bioavailability.[21] When complexed with phytates or tannins, nonheme iron absorption is decreased, but when consumed with ascorbic acid, nonheme iron absorption is greatly increased.[22] The presence of ascorbic acid in meals containing inhibitors of iron absorption, such as phytate in the fiber content of grains, nuts, seeds, and legumes, greatly increases absorption of nonheme iron and may serve as a method of mitigating the risk for iron deficiency anemia for plant-based diets on hemodialysis. Additionally, patients can lose anywhere from 28% to 40% of ascorbic acid during a single dialysis session.[23–25] Increasing ascorbic acid consumption for iron absorption could have the additional benefit of replenishing ascorbic acid losses due to dialysis.[26]

Chronic inflammation in patients on dialysis also increases the risk for anemia of inflammation, wherein cytokines (such as interleukin-1 [IL-1] and interleukin-6 [IL-6], and tumor necrosis factor [TNF-α]) stimulate the overproduction of the iron-regulatory protein hepcidin.[27] Hepcidin excess then increases the endocytosis and degradation of ferroportin, which reduces the amount of iron available for hemoglobin synthesis.[28] In these cases, iron sequesters inside of macrophages resulting in iron supplement-refractory iron deficiency anemia. A 6-week randomized control trial showed a significant decrease in serum levels of TNF-α, IL-6, and interleukin-8 when patients on dialysis receiving 10 or 20 g/day of fiber supplementation were compared to a placebo group.[29,30] By consuming a whole-food, plant-based diet, patients on dialysis can increase their fiber intake and may reduce the level of inflammatory cytokines that propagate anemia of inflammation.

5 | POTENTIAL RENAL ACID LOAD

An additional benefit of the consumption of plant foods is the reduction in the net dietary acid load and the associated benefits that come with it for patients with kidney disease, which is not limited to improvements in serum potassium. Metabolic acidosis is a common complication of kidney disease as the nephron loses the ability to excrete acid. As acid accumulates, compensatory mechanisms to increase acid excretion lead to increased levels of angiotensin II, aldosterone, and endothelin-I, which can lead to a further decline in kidney function.[31] Several studies have shown that treatment of metabolic acidosis can temper this process and reduce the rate of progression of kidney disease.[31]

Conventional treatment of metabolic acidosis involves the use of oral alkali therapy, but several trials of patients in varying stages of kidney disease have shown that the use of fruits and vegetables can produce similar improvements in metabolic acidosis and reductions in the progression of kidney disease when compared to conventional oral alkali therapy.[10] Further, these studies have shown additional improvements in blood pressure and weight due to the lower sodium load and higher fiber content of this treatment option.[32] The use of fruits and vegetables over oral alkali therapy was also demonstrated to significantly reduce low-density lipoprotein cholesterol and lipoprotein (a). The typical amount of fruits and vegetables consumed was two to four cups per day and involved foods that are widely available for many patients.[33]

Despite the active inclusion of plant foods into the diets of patients with renal disease, no significant differences in serum potassium levels were seen in these studies. However, it should be noted that patients with serum potassium levels greater than 4.6 mEq/L were excluded. Nonetheless, data from patients with stage IV CKD and lasting 1 year did not show any increase in serum potassium levels from baseline.[34]

Finally, metabolic acidosis may also induce PEW in patients on dialysis.[35] The potential amelioration of metabolic acidosis in patients on dialysis may also have downstream effects of preventing or even treating PEW. In one small study of patients with stage III and stage IV CKD, those eating a plant-based diet for 6 months actually had better dietary compliance and caloric intakes than their counterparts eating an animal-based diet.[14]

6 | SERUM POTASSIUM

Historically, plant-based diets have been thought to raise serum potassium levels in patients with end-stage kidney disease (ESKD). This assumption was based on the potassium content of plant-based foods and the reduced capability of the kidney to excrete potassium in the urine. This logic has been the basis for the restriction of many potassium-containing plant-based foods within a “renal diet.” However, emerging evidence may suggest otherwise.

Several observational studies have shown that dietary potassium from omnivorous diets correlates minimally, if at all, with serum potassium levels in patients with ESKD on dialysis.[4,11,36] Similarly, those consuming variations of plant-based diets have also demonstrated an absence of hyperkalemia.[17,37] There are several reasons explaining this apparent lack of association between dietary potassium consumption and increased serum potassium levels, especially among those consuming plant-based diets. The first lies with the bioavailability of potassium. It is generally accepted that the bioavailability of potassium salts and supplements is near 100%. However, it has been theorized that the presence of cell walls in plant-based foods limits the bioavailability of potassium in these foods.[38] Indeed, several studies, using urine recovery methods, have demonstrated that the bioavailability of potassium in these foods may be no more than 50% to 60%.[38]

However, not all studies are in agreement. Some studies have shown an apparent absorption of potassium being greater than 85%.[39,40] A possible explanation for these discordant findings is the variable fecal excretion of potassium found in plant-based foods, particularly in the setting of reduced renal function. The fiber content of foods affects stool volume and frequency, which will affect fecal potassium excretion.[4] Fecal excretion of potassium is also an important vector of potassium elimination in those with kidney disease as it has been shown to increase significantly. The increased excretion of potassium is mediated by potassium being secreted into the large intestines at a higher rate in those with kidney disease than those without.[9,41,42] In patients on dialysis, up to 35% to 80% of dietary potassium may be excreted by this manner.[43,44] However, 63% of patients on hemodialysis have constipation, which will prevent fecal excretion of potassium and may be related to the relatively low fiber amounts consumed by patients on dialysis (averaging 15.4 g/day).[45,46]

Another factor affecting serum potassium levels include the relative acid or base contribution of foods. As previously stated elsewhere, foods containing natural alkali will facilitate the intracellular movement of potassium.[47] Similarly, foods that contain carbohydrates will promote the insulin-facilitated movement of potassium intracellularly.[4,47] Further, the consumption of unrefined carbohydrates will prevent and treat insulin resistance, which may further assist in tempering the rise in serum potassium.[48] Additional variables affecting serum potassium levels include the concomitant use of medications that predispose to hyperkalemia, like nonsteroidal anti-inflammatory drugs (NSAIDs), beta-blockers, angiotensin-converting enzyme (ACE) inhibitors, angiotensin receptor blockers (ARBs), potassium-sparing diuretics, and others.

Although the consumption of plant-based foods is likely not as important in the development of hyperkalemia as previously thought, caution should still be exercised given the limited number of studies. Particularly, foods like juices, sauces, dried fruits, and foods excessively high in potassium (like molasses and raw beans) can contribute to a high amount of potassium being consumed in a relatively short amount of time, leading to postprandial hyperkalemia, and should be avoided.[5] In addition, the use of potassium additives in processed foods may contribute to the difficulties of serum potassium control as these additives are thought to have a greater bioavailability compared to potassium from whole foods[49] and should also be avoided.

7 | CARBOHYDRATE INTAKE

One of the leading causes of renal replacement therapy is type 2 diabetes mellitus (T2DM), which gives rise to increased clinical problems.[50] Therefore, a common concern when pivoting to a plant-dominant diet is increased simple carbohydrate intake in turn increasing the risk for or exacerbating preexisting uncontrolled metabolic syndromes, such as T2DM.[51] As meat and other animal products are reduced in the diet, carbohydrates are typically increased to take their caloric and nutritional place. The nutritional quality of the diet, however, must be maintained in order for a more plant-based diet to be nutritionally sound and comprehensive. Specifically, intake of simple and refined carbohydrates must be monitored and limited as diets containing large quantities of these foods have been linked to increased risk of metabolic disorders, primarily by promoting insulin resistance through beta-cell exhaustion.[52] It is important to note that while dialysis patients have a higher protein requirement than those with CKD stages 3 and 4, protein intake has been associated with increased insulin resistance in CKD while a decrease in protein intake has been associated with improved insulin sensitivity.[53] In order to prevent the deleterious effect of a higher carbohydrate diet on kidney health and diabetes risk, specific food choice is highly important.

Research suggests that a plant-dominant diet built on a foundation of complex carbohydrates is best to decrease T2DM risk.[48] For example, the Adventist Health Study 2 of 2009 demonstrated that when simply comparing those who follow a vegan diet to those who are nonvegetarians, the prevalence of T2DM decreases from 7.6% to 2.9% after accounting for differences in body weight.[54] Other cohort studies support the idea that a plant-based diet can not only decrease the risk of T2DM but also limit diabetes-related complications including lower extremity amputations, renal disease, and visual impairment.[48] However, simply following a plant-dominant or plant-based diet is not immunity against developing T2DM. The quality of the diet also plays a significant role in disease risk. Many plant-based foods such as artificially sweetened beverages, refined carbohydrates, and sweets can be detrimental to health. An unhealthy plant-based diet is positively associated with T2DM after body weight adjustment.[55]

There is evidence to suggest that following a plant-dominant diet or a whole-food, plant-based diet composed of foods that are not heavily processed or refined, and thus higher in fiber and lower in lipids and protein, can not only slow the progression of CKD but also decrease the risk of T2DM development.[56] Specifically, a median daily intake of approximately 27 g of fiber can reduce both serum urea and creatinine levels in CKD patients.[46] Plant-dominant diets are also linked with lower rates of inflammation, which may be beneficial in ameliorating CKD and minimizing T2DM risk.[56] Evidence suggests, therefore, that the source of carbohydrates, fats, and proteins plays a significant role in both the prevention and proper management of T2DM for the general population as well as for those with CKD.

8 | MEAT SUBSTITUTES

The need for increased protein consumption while receiving renal replacement therapy is well known and accepted.[57] Recently, there has been a significant increase in the creation and availability of more sophisticated plant-based meat substitutes in the form of burgers, sausages, chicken, and fish. The relatively new plant-based meat substitutes are designed for omnivores to enjoy by mimicking the experience of eating animal-based products, while providing vegetarians and vegans more protein options.[58] Two of the trailblazing companies behind this new generation of plant-based meat substitutes are Impossible Foods® and Beyond Meat®. Both are available to consumers in various fast-food chains, restaurants, and supermarkets in North America, demonstrating the marketability and high palatability of these newer plant-based products. Compared to traditional and previously available plant-based protein options, such as soy, tempeh, or black bean burgers, these new plant-based substitutes are innovative and have allowed for greater consumption of plant-based foods.

While these products could be a gateway for dialysis patients to consume a more plant-dominant diet, a deeper evaluation of the nutrient content is warranted. Notably, because of their ingredients, these meat substitutes are considered ultra-processed foods.[59] Beyond Meat® utilizes pea protein isolate, and Impossible Foods® uses soy protein isolate instead of whole foods.[58,59] Ultra-processed foods can be of concern since they are calorically dense and contain minimal fiber and nutrients.[59] Despite these plant-based options featuring similar amounts of calories (kcal) and protein as their animal-based counterparts while being cholesterol free, they also contain large amounts of sodium, total fat, saturated fat, and iron (Table 3). It may not be beneficial for individuals receiving dialysis therapy to consume these meat alternatives, particularly because of the large amount of sodium included in these products, which could lead to poor fluid management. Imbalances of fluid management due to excessive sodium and fluid intakes contribute to increases in fluid retention, blood pressure, and cardiovascular risks.[60]

TABLE 3 Nutritional comparison of beef with plant-based meat substitutes

	Beef	Impossible burger	Beyond burger	Bean burger
kcal (g/100 g)	260.00	212.24	230.00	177.00
Fat (g/100 g)	16.82	12.39	15.93	6.30
Saturated fat (g/100 g)	6.45	7.08	3.54	1.44
Protein (g/100 g)	25.54	16.81	17.7	15.70
Cholesterol (mg/100 g)	87.00	0.00	0.00	5.00
Carbohydrate (g/100 g)	0.00	7.96	4.42	14.27
Dietary fiber (g/100 g)	0.00	2.65	1.8	4.90
Sodium (mg/100 g)	397	327	310	569
Iron (mg/100 g)	2.47	3.72	3.72	2.41
Potassium (mg/100 g)	302	540	280	333
Phosphorus (mg/100 g)	192	133	Unavailable	206

Source: Adapted from He et al.[61] with data from the United States Department of Agriculture.[62]

Some dialysis patients may have additional needs for more energy (kcal) than others, which could lead to the assumption that ultra-processed foods are beneficial. However, consideration regarding all nutrients in ultra-processed foods should be prioritized. The plant-based meat alternatives, while comparable to beef in kcal, contain more carbohydrates than beef. This can become an issue for those on carbohydrate-restricted diets who may not have considered the amount of carbohydrates when deciding which product to consume. Additionally, it has been observed in an otherwise healthy population that the consumption of ultra-processed foods not only increases energy intake but also increases carbohydrate intake and leads to weight gain.[58,59] In the dialysis patient population, the outcome from eating ultra-processed foods might not be appropriate, especially for those already facing issues with weight or carbohydrate control.

Heme iron is generally found in animal products, whereas nonheme iron is found in plant products.[63] However, to create the "bleeding" effect in plant-based burgers, the heme is made from genetically engineered yeast and soy leghemoglobin.[64] As noted previously, individuals on dialysis therapy are susceptible to low iron levels due to blood loss in the dialyzer, impairment or decreases of iron transport, frequent laboratory draws, and lack of iron-rich foods in the diet.[65] For these patients, an increase in iron stores using heme iron may be beneficial because of the rapid bioavailability of heme iron compared to nonheme iron.[66] However, these patients are treated in-center during treatments to restore iron stores and are routinely measured often and with various markers, including hemoglobin.[67] The consumption of plant-based heme iron should be closely monitored to ensure patients are not at risk of iron overload from the combination of in-center injections and dietary iron. An association between heme iron intake and excess body stores of iron demonstrates an increased risk of T2DM.[66] Individuals at risk for developing T2DM currently on dialysis therapy should reconsider consuming large amounts of heme iron.

The way that individuals are consuming these plant-based meat substitutes is also a factor to consider. These items are most likely not being consumed as a single item without any toppings or sides because most consumers are purchasing the newer plant-based burgers from fast-food chains and restaurants and not purchasing the item from supermarkets and cooking it themselves at home. The additional toppings and sides can contribute to increases in calories, sodium, and unhealthy fat, which can lead to poorer health outcomes, particularly for those on dialysis.

9 | CONCLUSION

The benefits of a plant-based diet in many populations, including hemodialysis patients, are unequivocal and have been previously documented. As with any diet and especially in this patient population, potential pitfalls of converting to a more plant-based diet from a traditionally prescribed omnivore diet are inevitable. However, since the benefits outweigh the risks, diet conversion should be considered with proper dietary counseling and medical management, and given the proper proactive considerations, these pitfalls can be avoided.

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