



A Survey Study on Soy Food Consumption in Patients with Chronic Kidney Diseases

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Abstract

Chronic kidney disease (CKD) is one of the major and exacerbating global health burdens, which is characterized by no curative treatments and high morbidity and mortality. Since malnutrition has become an important factor determining the final clinical outcomes of CKD, soy products, high-quality plant-based sources of proteins and other nutrients, are recommended by many physicians for CKD patients. However, it has been reported that adherence to this dietary advice among those patients is low. In order to dissect the potential reasons behind this phenomenon and to subsequently develop target intervention to improve the current situation, we designed and conducted a self-administered questionnaire survey in 3 medical centers in China. Total 570 patients responded to our survey and data analysis reveals that 85.6% of the respondents were aware of the necessities of high-quality protein diets for CKD patients, but only 41.9% of patients knew that soy foods provide high-quality proteins needed. In contrast, up to 90.4% of patients were affected by the notion that patients with CKD should avoid soy products. Besides, comparing with other groups, higher percentage of patients undergoing peritoneal dialysis recognized soy products as foods with high-quality proteins, however, as many as 68.8% of them did not consume any soy foods due to the concerns of adverse effects on the progress of CKD. Our data suggest that a significant portion of patients with CKD do not consume soy foods, which could be mainly resulted from their misconception towards soy products delivered by medical workers or social media. Evidence-based updated education of patients and medical workers on soy foods would be a necessary strategy for improving nutrition status of CKD patients and their clinical outcomes.

Keywords

plant-based protein diet, soy products, dietary education, chronic kidney disease, questionnaire

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What do we Already Know about this Topic?

Although soy products are recommended by many physicians for Chronic kidney disease (CKD) patients, a significant portion of patients with CKD do not consume soy foods, which could be mainly resulted from their misconception towards soy products delivered by medical workers or social media.

How Does Your Research Contribute to the Field?

In this survey study, it does dissect the potential reasons behind this phenomenon and provide some insightful information for controlling the progress of CKD from the point of view of diets or non-pharmacological methods.

What are Your Research's Implications Towards Theory, Practice, or Policy?

To improve the situation that significant numbers of CKD patients are not being directed by current understanding of high-quality plant-based protein diets, which could be essential for maintenance of kidney functions, updated training or education in medical staff in related fields on soy products could be essential.

Introduction

Chronic kidney disease (CKD) is a major global health issue, with approximately 10% of adults worldwide are affected by some forms of CKD, which cause 1.2 million deaths and 28 million years of life lost annually.^{1,2} Nutrient therapies are recommended for intervention of kidney disease and complications. Currently, digestibility corrected amino acid score (DIAAS) is a worldwide acknowledged approach for determining protein quality and proteins with DIAAS equal to or higher than 75 are defined as high-quality according to Food and Agricultural Organization of the United Nations (FAO) DIAAS report.^{3,4} Since 1990s, supplement with high-quality dietary protein rather reducing protein intake has been highly recommended for patients with kidney diseases. The National Kidney Foundation's Kidney Disease Outcomes Quality Initiative (KDOQI) 2020 has provided evidence-based protein intake suggestions for CKD patients, which is .55–.6 g/kg body weight for non-diabetics patients with CKD 3-5 or 1.0–1.2 g/kg body weight (higher protein intake) for CKD patients undergoing maintenance hemodialysis and peritoneal dialysis.⁵ Besides, the KDOQI 2020 guidelines also demonstrated that high-quality plant-based diet may have positive biological and clinical benefits *via* diverse mechanisms.⁵ The high-quality plant-based diet may also ameliorate complications and comorbidities of CKD, such as cardiovascular disease, infection and acute kidney injury.⁶⁻⁸ A recent community-based cohort study showed that higher obedience of healthy plant-based diet was related to favorable CKD outcomes, which lowered the risk of CKD and slow eGFR decline in CKD patients.⁹ Soy products have attracted remarkable attention in recent studies, because they are representative sources of plant-based proteins, and the only plant-based ones that can adequately provide all the essential amino acids to meet nutritional needs in human.^{4,10} Nearly 90–95% of the soy content is made up by a globular storage protein with 2 subunits.¹¹ As measured by the DIAAS, soy protein is commensurable to meat, milk and eggs in protein property.¹⁰ Furthermore, soy protein consumption, when

compared to animal protein consumption, showed remarkable effects on lowering serum creatinine (SCR) and serum phosphorus concentrations in pre-dialysis CKD patients.¹²⁻¹⁴ In the past decades, it had been prevailing that patient with CKD should not consumed soy products due to the skeptics on their nutrition significance. Shadowed by this concept, CKD patients reduced or even avoid taking soy products, here referred to minimally processed soy foods, such as soybeans, tofu, tempeh, edamame, and unsweetened soy milks etc.¹⁵ In recent years, with the confirmation of soy products as qualified sources of proteins, including soy foods as part of CKD patients' dietary treatment could have clinical importance.^{10,16} However, in clinics, there are still quite a few CKD patients, even some medical workers who are uncertain about or continue to misunderstand the importance of consuming soy products.¹⁷⁻¹⁹ Regarding to this phenomenon, we conducted a self-administered questionnaire survey in patients at different CKD stages in order to investigate their knowledge and daily consumption of soy products in three medical centers in China. Our study demonstrated that although soy products have been classified as high-quality protein diets, knowledge and recognition of soy products in CKD patients has not been updated correspondingly. Therefore, education of soy foods incorporated with current scientific results could be valuable as a non-pharmacological intervention in CKD patients.

Methods**Enrollment of 570 Patients**

A self-administered questionnaire survey was conducted over a 6-months period, from February 1, 2020 to July 30, 2020, in three medical centers, in Beijing, China. Chronic kidney disease patients, including hemodialysis and peritoneal dialysis patients from North and South Campuses of Guang'anmen Hospital of the China Academy of Chinese Medical Sciences, and peritoneal dialysis patients from the Department of Nephrology, Fangshan District Hospital of Traditional Chinese

Medicines were enrolled in this survey. Chronic kidney disease was diagnosed and classified according to “Kidney Disease: Improving Global Outcomes” (KDIGO) 2012 classification scheme based on prognosis of CKD by GFR and Albuminuria Categories.²⁰ The study was approved by the Ethics Committee of Guang’anmen Hospital, China Academy of Chinese Medical Sciences (Project identification code: 2019-099-KY-01). Researchers explained the study purpose to CKD patients and all enrolled patients signed informed consent forms.

Design of Questionnaire Survey

The survey questionnaire was created on an online platform named “Wenjuanxing” (www.wjx.cn), a platform equivalent to Amazon Mechanical Turk,²¹ in China. Composition of the questionnaire was designed by researchers and physicians in Guang’anmen hospital based on their clinical expertise. To validate that the questions in the questionnaire are understandable and suitable for CKD patients with different cultural and educational backgrounds, pre-test was conducted in peritoneal dialysis patients before the final version was released to all the participants. The respondent can fill out the questionnaire through Wenjuanxing App or WeChat link on mobile devices, such as smartphones and tablets. Researchers can guide patients through the process in both inpatient and outpatient settings if needed. An attention notice was designed at the end of the survey to ensure that the respondent answered all the questions before submission. Each respondent can only complete and submit the survey once.

Measurements

The questionnaire included 3 parts with total 14 questions (See Table 1): the first part was to collect demographic information of the respondents; The second part was the information of CKD status of patients; The third part was to assess the respondents’ knowledge of soy products. Question 11 and 13 in Part 3 are multi-choice questions since most patients may obtain dietary information from more than one source and their preference for soy foods may be decided by multiple factors.

Data Collection and Statistical Analysis

The data were collected by researchers and downloaded from the Wenjuanxing digital platform.

All statistical analyses were performed using SPSS Statistics version 23 (SPSS Inc., Chicago, IL). Data are expressed as frequency (percentage). Chi-square test was used to determine the association between the variables in the first two parts of this questionnaire and respondents’ knowledge of eating soy products. For all analyses, a *P*-value < .05 was considered to be statistically significant.

Table 1. Composition of Questionnaire Survey.

Part 1
1. Gender
Male
Female
2. Age
3. Education
Primary school or lower
Middle school or higher
4. Height (cm)
5. Weight (kg)
Part 2
6. Are you a dialysis patient?
No
Hemodialysis
Peritoneal dialysis
7. What is your recent blood creatinine value? (μmol/L)
Part 3
8. During your treatment of CKD, were you informed that CKD patients should have high-quality protein diets?
Yes
No
9. Do you think soy products are good sources of high-quality proteins?
Yes
No
No idea
10. Were you informed that CKD patients should not eat soy products, such as soybeans, tofu, tempeh, edamame, and unsweetened soy milks?
Yes
No
11. Where did you get the knowledge concerned with the effect of soy products on CKD?
Medical workers
Internet, TV
Other CKD patients, family member
12. How do you feel about soy products?
Do not dare to eat
Do not like to eat
No preference
13. If soy foods are not dietary choices for you, what could be the reason(s)?
Proteinuria
Hematuria
High blood uric acid
High blood creatinine
It was suggested by medical workers
Other reasons
14. How often do you eat soy foods since you were diagnosed with CKD?
Never
Occasionally, less than before the diagnosis
The same as before the diagnosis
Eat more soy foods to replace all or part of animal protein for consumption

Results

Demographic Characteristics of Respondents

The demographic characteristics of 570 respondents were reported in Table 2. There was no difference in the male-female distribution. In this survey, 421 (73.9%) were CKD patients ≤ 60 years of age and 149 (26.1%) were older adults > 60 years old. There were 195 CKD patients (34.2%) who had primary school or lower education and 375 CKD patients (65.8%) had middle school or higher diploma. Among all the respondents, most of them (407, 71.4%) were not dialysis patients, while 128 (22.5%) and 35 (6.1%) respondents received or were receiving peritoneal dialysis or hemodialysis, respectively.

The Respondents' Knowledge of Soy Products

Despite the growing proposal of soy products for CKD patients, clinically, we can still notice that a large number of patients cannot meet recommended dietary advice.⁹ In order to find out the possible reasons for this phenomenon, we investigated 570 respondents' knowledge of soy products. The results were summarized in Table 3. In this survey, 488 (85.6%) patients were informed that CKD patients should have high-quality protein diets, while 82 (14.4%) patients were not. We further conducted a stratified analysis to investigate the influence of CKD treatment modality on respondents' perception about this question. The results showed that, although the number of respondents in each subgroup varies greatly, more than 50% of respondents, which are 345 (84.8%) non-dialyzed, 116 (90.6%) peritoneal dialysis and 27 (77.1%) hemodialysis patients were informed that they should have high-quality protein diets. Interestingly, only 239 (41.9%) CKD patients answered yes to the question of whether soy products are good sources of high-quality proteins, and the rest patients answered either no (197, 34.6%) or no idea (134, 23.5%) in this question. In addition, to our surprise, more than 90% of respondents were affected by the notion that CKD patients should not eat soy products. These findings clearly demonstrate the urgent need for updated knowledge and guidance on soy foods in CKD patients for better dietary intervention. We further analyzed the information sources from which CKD patients learned about soy foods. Most (435, 76.3%) CKD patients received dietary treatment-related information from medical workers, and the information or suggestion delivered by medical workers may also indirectly influence two other sources, internet/TV (217, 38.1%) or other CKD patients/family members (170, 29.8%), in the survey. We also found that 204 (35.8%) patients showed no preference for soy foods, 325 (57%) patients stayed away from soy foods for healthy concerns, and 41 (7.2%) of them avoided soy products due to personal preference. For the specific group of patients with healthy concerns about soy foods (don't dare to eat) ($n = 325$), the major reason is the development of clinical symptoms, such as

Table 2. The Demographic Characteristics of Respondents.

Variable	N (%)
Gender, n (%)	
Male	269 (47.2)
Female	301 (52.8)
Age, n (%)	
≤ 60	421 (73.9)
> 60	149 (26.1)
Education, n (%)	
Primary school or lower	195 (34.2)
Middle school or higher	375 (65.8)
Dialysis patient, n (%)	
No	407 (71.4)
Hemodialysis	128 (22.5)
Peritoneal dialysis	35 (6.1)
Recent blood creatinine value ($\mu\text{mol/L}$)	
≤ 100	163 (28.6)
101–999	334 (58.6)
≥ 1000	6 (1.1)
Do not remember	67 (11.8)

proteinuria, hematuria, high blood uric acid, and high blood creatinine. Within this group, the concerns of 137 (42.2%) patients were resulted from previous misconception on soy foods conveyed by medical workers, which further emphasizes the significance of renewal of knowledge in medical workers during long-term treatment of the disease. In the survey, only 110 (19.3%) of CKD patients maintained their eating habits of soy products as before the diagnosis, while 305 (53.5%) of them consumed soy foods less frequently than before or occasionally. 113 (19.8%) of them stopped eating soy foods completely, and in contrast, 42 (7.4%) of them used soy products to replace all or part of dietary animal proteins. These results suggests that some patients may not meet recommended dietary advice on consumption of soy foods.⁶

Variation in the Knowledge of Soy Products as Sauces of High-Quality Proteins in CKD Patients

To identify the protentional factors that affect CKD patients' knowledge of intaking soy products, we used Chi-square test to determine its correlations with demographic characteristics or medical conditions in the questionnaire. The results were summarized in Table 4 and we found that age ($\chi^2 = 11.574$, $P = .003$) and dialysis ($\chi^2 = 28.087$, $P < .001$) were the two factors with the strongest correlations with CKD patients' understanding of whether soy has high-quality proteins. Compared with CKD patients older than 60 years, higher percentage of younger patients considered soy products belong to high-quality protein, suggesting that clinicians should pay more attention to older patients when delivering the updated dietary education, because aging is also one of the

Table 3. The Respondents' Knowledge of Soy Products.

Questions	N (%)
During your treatment of CKD, were you informed that CKD patients should have high-quality protein diets? n (%)	
Yes	488 (85.6)
Non-dialysis	345 (84.8)
Peritoneal dialysis	116 (90.6)
Hemodialysis	27 (77.1)
No	82 (14.4)
Non-dialysis	62 (15.2)
Peritoneal dialysis	12 (9.4)
Hemodialysis	8 (22.9)
Do you think soy products are good sources of high-quality proteins? n (%)	
Yes	239 (41.9)
No	197 (34.6)
No idea	134 (23.5)
Were you informed that CKD patients should not eat soy products, such as soybeans, tofu, tempeh, edamame, and unsweetened soy milks? n (%)	
Yes	515 (90.4)
No	55 (9.6)
Where did you get the knowledge concerned with the effect of soy products on CKD?	
Medical workers	435 (76.3)
Internet, TV	217 (38.1)
Other CKD patients, family member	170 (29.8)
How do you feel about soy products? n (%)	
Do not dare to eat	325 (57)
Do not like to eat	41 (7.2)
No preference	204 (35.8)
If soy foods are not dietary choices for you, what could be the reason(s)? n (%)	
Proteinuria	177 (50.4)
Hematuria	26 (8)
High blood uric acid	73 (22.8)
High blood creatinine	104 (32)
Suggested by medical workers	137 (42.2)
Other reasons	24 (7.4)
How often do you eat soy products since diagnosis with CKD? n (%)	
Never intake	113 (19.8)
Occasionally, less than before	305 (53.5)
The same as before the diagnosis	110 (19.3)
Use soy products to replace all or part of animal proteins in diet	42 (7.4)

risk factors accelerating the progression of kidney disease. Besides, the highest percentage of patients answering yes to the question was found in the group of peritoneal dialysis. This could be because peritoneal dialysis patients need to perform the procedures by themselves at home, they therefore could contact physicians more frequently and have better chance in receiving updated information of soy products. Another potential explanation is that operation of the procedures encouraged patients in this group to follow current progress in CKD treatment closely. There was no statistical significance found in this correlative analysis for gender and education.

As shown in [Table 5](#), we then analyzed the associations between the variables in [Table 4](#) and CKD patients' attitudes

towards intaking soy products. The results showed that the proportion of female respondents who did not dare to eat soy product was larger than that of males, but the proportion of men who had an indifferent attitude towards whether or not to eat soy products is higher than that of women. Interestingly, among all the patients who did not dare to eat soy products ($n = 325$), peritoneal dialysis patients have a higher proportion than other CKD patients. Regarding to this result, peritoneal dialysis patients might be more cautious in intaking soy foods, because they may have symptoms, such as proteinuria, high blood creatinine, and fatigue, but at the same time, they had to perform the dialysis procedures by themselves at home. With the uncertainties of how their diseases would develop and effects of soy products, they could be

Table 4. Results of Chi-Square Test for the Association between Demographic Characteristics or Medical Condition and the Knowledge of Soy Products as High-Quality Protein Sauces in CKD Patients.

Variable	Yes	No	No Idea	χ^2	P
	n = 239	n = 197	n = 134		
Gender, n (%)					
Male	110 (40.9)	85 (31.6)	74 (27.5)	4.893	.087
Female	129 (42.9)	112 (37.2)	60 (19.9)		
Age, n (%)					
≤60	187 (44.4)	150 (35.6)	84 (20)	11.574	.003**
>60	52 (34.9)	47 (31.5)	50 (33.6)		
Education, n (%)					
Primary school or below	82 (42.1)	67 (34.4)	46 (23.6)	.005	.997
Middle school or above	157 (41.9)	130 (34.7)	88 (23.5)		
Dialysis patient, n (%)					
No	164 (40.3)	145 (35.6)	98 (24.1)	28.087	<.001**
Peritoneal dialysis	83 (64.8)	34 (26.6)	11 (8.6)		
Hemodialysis	13 (37.1)	12 (34.3)	10 (28.6)		

Table 5. Results of Chi-Square Test between Criteria and the Attitude towards Eating Soy Products in Respondents.

Variable	Do not Dare to Eat	Do not like to Eat	No Preference	χ^2	P
	n = 325	n = 41	n = 204		
Gender, n (%)					
Male	148 (55)	11 (4.1)	110 (40.9)	10.885	.004**
Female	177 (58.8)	30 (10)	94 (31.2)		
Age, n (%)					
≤60	240 (57)	28 (6.7)	153 (36.3)	.796	.672
>60	85 (57)	13 (8.7)	51 (34.2)		
Education, n (%)					
Primary school or lower	119 (61)	16 (8.2)	60 (31.8)	3.344	.188
Middle school or higher	206 (54.9)	25 (6.7)	144 (38.4)		
Dialysis patient, n (%)					
No	221 (54.3)	27 (6.6)	159 (39.1)	13.373	.01*
Peritoneal dialysis	88 (68.8)	11 (8.6)	29 (22.7)		
Hemodialysis	16 (45.7)	3 (8.6)	16 (45.7)		

more skeptic on soy foods than other patients. Nevertheless, there was no statistical significance in this analysis for age and education.

Discussion

Chronic kidney disease is a major and growing global health burden, which is characterized by no cure for this disease and with high morbidity and mortality.²² Previously, it was proposed that CKD patients should restrict the dietary protein consumption, since excessive protein intake would result in hyperfiltration and hypertensin of glomeruli, thereafter deteriorating the renal function.^{23,24} In recent years, as one of the non-pharmacological strategies suggested in The KDIGO guidelines 2021,^{22,25} high-quality of plant-based protein

diets, especially substituting animal protein with soy protein,²⁶ have been increasingly advocated for the preservation of kidney function in CKD patients. These diets can also lead to salutary reconstruction in the gut microbiome, which may modulate uremic toxin generation.²⁷

Soy products are representative sauces of high-quality plant-based proteins, which are recognized as one type of the essential meals across the globe.²⁸ Mounting evidence revealed that soy protein consumption could improve the lipid profile and renal function, such as the decrease of urinary albumin excretion, SCR and serum phosphorus concentrations in animal models and CKD patients.^{12,16,29,30}

Despite the increasing advocacy of high-quality plant-based protein intake for CKD patients, there is still a large number of patients cannot meet recommended dietary advice.³¹ A recent

study also reported that up to 70% CKD patients could not adhere to dietary suggestions from physicians.³² In this study, we enrolled 570 CKD patients and conducted self-administered questionnaires to investigate their knowledge on soy products in three medical centers.

In our results, although 85.6% of the included CKD patients have heard that controlling of kidney disease requires high-quality protein diets, but only 41.9% of patients knew that soy products belong to high-quality protein foods, and up to 90.4% of patients have ever heard that they should not eat soy products (Table 3). These results demonstrate the significance of delivering updated dietary education and individualized non-pharmacological guidance for CKD patients. From the analysis of subgroups, although higher percentage of peritoneal dialysis patients knew that soy products are a good source of high-quality proteins, the proportion of this group that did not dare to eat soy products is as high as 68.8% (Table 5). To some extent, this reflects the CKD patients' uncertainty and misconception of intaking soy products and high-quality protein diets. Besides, 57% of the respondents did not dare to eat soy products, which may also imply that this concept significantly limits the choices of foods in CKD patients who are vegetarian or consume soy products regularly. Therefore, enhancing dietary education on high-quality protein diets, especially on soy foods, in both medical workers and patients has great potential in ameliorating the progress of CKD.

Previously, it was suggested that CKD patients should not consume soy products, since they were thought to be nutritionally inadequate.¹⁷ This advice was based on the misconception that soy products lack essential amino acids which are rich in animal protein and necessary for gastrointestinal bioavailability for CKD patients.¹⁷ It was also believed that soy products contain too much non-essential amino acids, which can cause amino acid metabolism disorders and nitrogen retention in patients with renal insufficiency.^{18,19} However, in the recent decades, studies have shown the favorable effects of soy products in patients with CKD.^{12,30} They have been categorized into high-quality protein diets which are highly recommended for CKD patients.¹⁶ A meta-analysis which consists nine trials, indicated the renal protective effects of soy proteins on SCR and serum phosphorous concentrations in pre-dialysis CKD patients.¹² Bioactive ingredients, polyphenols, in soy products, have been related to 37% relative reductions in chronic disease and cardiovascular disease.^{33,34} In addition, in vivo experiments, treatment with polyphenol was able to decrease blood pressure in rats, which was associated with endothelium-dependent relaxation in blood vessels by inducing the gene expression of nitric oxide synthase.³⁵

In terms of sources of knowledge about consumption of soy products, our results confirmed that 76.3% of patients obtained related knowledge from medical workers, and 42.2% of patients who did not dare to eat soy products were advised by medical staff. Due to the long-term course of the

disease, some patients may learn about the necessity of limiting soy products consumption from medical workers in early years and have retained this conception since then. In addition, although there are many ways to acquire information in this digital world, suggestions from medical staff, especially physicians and nurses, are still the most reliable for patients. Therefore, continuously updating dietary knowledge in medical workers may play a critical role in the future treatment of renal disease in clinical practice.

In this survey study, although it is too early to come up with new interventions for CKD patients, it does provide some insightful information for controlling the progress of CKD from the point of view of diets or non-pharmacological methods.

Conclusion

The results from this self-administered questionnaire study suggest that significant numbers of CKD patients, especially those over 60, are not being directed by current understanding of high-quality protein diets, which could be essential for maintenance of kidney functions. To improve this situation, updated training or education in medical staff in related fields on soy products could be essential.

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Author Contributions

Conceptualization, L.F. and Y.D.; investigation, L.F.; resources, L.F. and Y.D.; data curation, L.F. and Y.D. and X.R.; data analysis, L.F.; writing—original draft preparation, Y.D.; writing—review and editing, L.F. and X.R.; supervision, L.F. and X.R.; funding acquisition, L.F. and X.R.; All authors have read and agreed to the published version of the manuscript.

Declaration of Conflicting Interests

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Ethical Approval

The study was conducted in accordance with the Declaration of Helsinki, and the protocol was approved by the Ethics Committee of

Guang'anmen Hospital (Project identification code: 2019-099-KY-01).

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