nefrología
Revista de la Sociedad Española de Nefrología
www.revistanefrologia.com

Original article

Reduction of potassium content of green bean pods and chard by culinary processing. Tools for chronic kidney disease☆

Montserrat Martínez-Pineda[a], Cristina Yagüe-Ruiz[a], Alberto Caverni-Muñoz[b], Antonio Vercet-Tormo[a,*]

[a] Departamento de Producción Animal y Ciencia de los Alimentos, Facultad de Ciencias de la Salud y del Deporte, Universidad de Zaragoza, Huesca, Spain
[b] Servicio de Nutrición y Dietética, Alcer Ebro, Zaragoza, Spain

ARTICLE INFO

Article history:
Received 8 June 2015
Accepted 25 March 2016
Available online 28 October 2016

Keywords:
Chronic kidney disease
Hyperkalemia
Potassium reduction
Food processing
Soaking
Double cooking
Dietary guidelines
Vegetables

ABSTRACT

Introduction: In order to prevent a possible hyperkalemia, chronic renal patients, especially in advanced stages, must follow a low potassium diet. So dietary guidelines for chronic kidney disease recommend limiting the consumption of many vegetables, as well as to apply laborious culinary techniques to maximize the reduction of potassium.
Objective: The aim of this work is to analyze potassium content from several vegetable, fresh products, frozen and preserved, as well as check and compare the effectiveness in potassium reduction of different culinary processes, some of them recommended in dietary guidelines such as soaking or double cooking.
Methods: Sample potassium content was analyzed by triplicate using flamephotometry.
Results: The results showed significant reductions in potassium content in all culinary processes studied. The degree of loss varied depending on the type of vegetable and processing applied. Frozen products achieved greater reductions than the fresh ones, obtaining in some cases losses greater than 90%. In addition, it was observed how in many cases the single application of a normal cooking reached potassium reductions to acceptable levels for its inclusion in renal patient diet.
Conclusion: The results shown in this study are very positive because they provide tools for professionals who deal with this kind of patients. They allow them to adapt more easily to the needs and preferences of their patients and increase dietary variety.

☆ Please cite this article as: Martínez-Pineda M, Yagüe-Ruiz C, Caverni-Muñoz A, Vercet-Tormo A. Reducción del contenido de potasio de las judías verdes y las acelgas mediante el procesado culinario. Herramientas para la enfermedad renal crónica. Nefrologia. 2016;36:427–432.

* *Corresponding author.*
E-mail address: vercet@unizar.es (A. Vercet-Tormo).

Reducción del contenido de potasio de las judías verdes y las acelgas mediante el procesado culinario. Herramientas para la enfermedad renal crónica

Palabras clave:
Enfermedad renal crónica
Hiperpotasemia
Reducción de potasio
Procesado de alimentos
Remojo
Doble cocción
Guías alimentarias
Verduras

RESUMEN

Introducción: Con el fin de prevenir una posible hiperpotasemia, los enfermos renales crónicos, especialmente en fases avanzadas, deben seguir una dieta baja en potasio. Para ello, las guías alimentarias para la enfermedad renal crónica recomiendan limitar el consumo de muchas verduras, así como aplicar laboriosas técnicas culinarias para reducir al máximo la cantidad de potasio.

Objetivos: El objetivo de este trabajo es analizar el contenido de potasio de varios productos vegetales (frescos, congelados y en conserva), así como comprobar y comparar la efectividad en la reducción de potasio de distintos procesos culinarios, algunos de ellos recomendados en las guías alimentarias, como son el remojo o la doble cocción.

Métodos: Se analizó el contenido de potasio de las muestras por triplicado mediante espectrometría de emisión atómica de llama.

Resultados: Los resultados mostraron reducciones significativas en el contenido de potasio en todos los procesos culinarios estudiados. El grado de disminución varió según el tipo de verdura y el procesado al que fue sometida. En los productos congelados se alcanzaron mayores reducciones que en los frescos, y en algunos casos se lograron pérdidas de potasio superiores al 90%. Además, se observó como en muchos casos la simple aplicación de una cocción normal dio lugar a reducciones de potasio hasta niveles aceptables para la inclusión en la dieta del enfermo renal.

Conclusión: Los resultados mostrados en este estudio son muy positivos, ya que aportan herramientas a los profesionales que tratan con este tipo de pacientes, lo que les permite adaptarse más fácilmente a las necesidades y preferencias de sus pacientes, así como incrementar la variedad en su dieta.

Introduction

Patients with chronic kidney disease (CKD) often have associated complications such as hyperkalemia or an increased risk of cardiovascular disease, which are in turn associated with an increased risk of mortality.[1–4]

As a result, patients with CKD have specific nutritional requirements. Intake of potassium, should be limited to 1500–2000 mg/day,[5,6] according to the stage of the disease and the specific situation of each patient.

To prevent hyperkalemia, patients should follow a diet low in potassium,[3] avoiding foods with a high natural potassium content, or those containing additives with potassium salts. Due to their high mineral, especially potassium, content, CKD patients must reduce the incorporation into their diet of many types of vegetables, among them green beans or green leafy vegetables.

In order to achieve the maximum reduction in the potassium content of these foods, nutritional and dietary guidelines for CKD[7–9] recommend presoaking the vegetables for a period of 12 and 24 h, with at least one exchange of water, and then double cooking with plenty of water. The double cooking technique consists in placing the vegetables in a pot with water at room temperature and then boil them. Once it begins to boil, remove the vegetables and place them in another pot with already boiling water and end the cooking there.

There are also other recommendations such as cutting them into small pieces, as small as possible and discarding the cooking broth. These recommendations are based on the loss of potassium and other soluble minerals in food due to passing it through cooking water.

These recommendations are frequently found in the guides provided to patients with CKD, but there are very few scientific studies that demonstrate the effectiveness of these methods, which are also long and laborious.[10–12]

The primary objective of this work is to analyze the reduction in potassium content of several fresh and processed vegetable products, the consumption of which is limited for patients with CKD, such as green beans, chard, mixed and diced vegetables, after subjecting them to soaking and different types of cooking. Because of the scant scientific evidence on the effectiveness of the recommendations usually provided to patients with CKD, this paper aims to test and compare different cooking techniques in order to optimize them, to try to increase the variety and the number of vegetable servings, and provide tools to professionals who deal with these kinds of patients.

Materials and method

Materials

3 types of green beans were studied: fresh, frozen and canned. The fresh flat beans (*Phaseolus vulgaris var. perona*) were grown in Almeria (Spain) and acquired from a distributor, while the frozen beans were purchased at a local supermarket. Prior to the various treatments, the fresh beans were washed and cut into 4 cm-long pieces. The frozen samples were thawed before applying any treatment.

Fresh, frozen and canned chard were also studied. The canned and frozen samples were purchased at a local supermarket, while the fresh samples, grown in Zaragoza (Spain), were purchased from a local distributor. Due to their large structural differences, stalk and leaf were studied separately. Before the different treatments, fresh chard leaves and stalks were separated and cut into 2 cm strips.

In order to compare the efficacy of domestic freezing, both green beans and chard, already washed and cut, were frozen at −18 °C in a domestic freezer for one month. They were subsequently treated in a similar manner to the industrially frozen samples.

In addition, 4 different brands of frozen mixed vegetables and diced vegetable salad were analyzed.

Method

5 different culinary techniques were studied: soaking; soaking followed by normal cooking (S + NC); soaking followed by double cooking (S + DC); normal cooking (NC); double cooking (DC). For all the techniques low mineralization natural mineral water was used.

The soaking was carried out at refrigeration temperatures for 12 h with a change of water at 4 h. Cooking times were adjusted to each product studied. For green beans 15 min; 4 min for chard leaves; 10 min for chard stalks. In NC the sample was added to boiling water while in DC time started counting when adding the sample to the second pot of boiling water.

The diced vegetable salad and mixed vegetables were cooked following the manufacturer's instructions. One NC was applied for 8 min, pouring the product without thawing. Canned samples, since it is a product ready for consumption, were not subjected to any treatment, only their potassium content was analyzed after washing them to remove excess canning liquid rich in salts. In all cases studied, the 100 g/1.5 L ratio was maintained for both soaking and cooking.

Each treatment was performed in triplicate and each sample was in turn analyzed in triplicate.

The potassium content was determined by flame photometry, following a validated method of analysis. Potassium contents are expressed in mg/100 g of edible portion (EP).

Statistical analysis

Statistical differences in the potassium content after application of the 5 culinary techniques for each type of sample were established by analysis of variance (ANOVA) and Tukey's test. *p*-Values <0.05 were considered statistically significant differences. Different statistical analyzes were performed using the GraphPad Prism 5 *software* (GraphPad Software, Inc., San Diego, CA, USA).

Results

Green bean pod

A loss of potassium was observed after application of the different culinary processes both for fresh and frozen green beans. The observed effect was greater in the latter. Table 1 shows the final potassium content (mg/100 g EP) of the different types of green beans, and the percentage of loss due to each type of culinary process.

In fresh green beans a reduction of 14.49% in the potassium content due to soaking was observed, with values of 147.95 mg/100 g EP. Cooking was also able to reduce the potassium to final contents of around 110 mg/100 g EP, without significant differences between applying a NC or a DC. It should be noted that in the fresh green beans an additive effect of soaking and cooking was also observed, which was not observed in the frozen green beans, which reduced the content to 75 mg/100 g EP. In the case of the home frozen green beans a similar behavior to those industrially frozen was observed, regardless of the type of culinary process applied.

While freezing alone does not affect the potassium content, it does promote loss during application of the studied culinary processes. In the case of industrially frozen green beans,

Table 1 – Potassium content and effect of different culinary processes in green beans.

Culinary process	Fresh		Home frozen		Industrially frozen	
	mg/100 g	% loss	mg/100 g	% loss	mg/100 g	% loss
Raw	210.9 (24.9)	–	202.5 (15.5)	–	170.1 (11.8)	–
Soaking	147.9 (23.2)	14.5 (4.1)[a]	9.9 (1.1)	90.7 (1.9)[a]	6.2 (2.2)	93.3 (2.5)[a]
NC	114.3 (13.1)	32.9 (3.5)[b]	41.8 (5.7)	64.3 (1.9)[b]	45 (5.9)	58.8 (5.8)[b]
DC	107.6 (8.3)	32.9 (4.9)[b]	32.7 (4.6)	69.8 (2.3)[c]	25.4 (1.7)	74.9 (1.3)[c]
S + CN	75.2 (12)	46.3 (2.3)[c]	3.1 (0.5)	96.4 (0.4)[d]	2.8 (0.3)	97.2 (0.3)[d]
S + DC	76.4 (6.6)	47.1 (4.1)[c]	3.7 (1.0)	96 (1.0)[d]	2.5 (0.9)	97.3 (1.1)[d]

Results shown as mean (standard deviation). Mean values with different letters (a, b, c . . .) in the same column indicate significant differences ($p < 0.05$) in potassium loss among the different culinary processes.
NC: normal cooking; DC: double cooking; S + NC: soaking + normal cooking; S + DC: soaking + double cooking.

Table 2 – Potassium content of canned products.

Product	mg/100 g EP	
Flat green beans		
Commercial brand 1	90 (4)	
Commercial brand 2	79 (5)	
Commercial brand 3	87 (6)	
Round green beans		
Commercial brand 1	126(2)	
Commercial brand 2	65 (2)	
Commercial brand 3	75 (4)	
Whole chard	Leaf	Stalk
Commercial brand 1	119 (4)	108 (7)
Commercial brand 2	92 (3)	88 (10)
Commercial brand 3	159 (2)	153 (4)
Chard stalks		
Commercial brand 1	130 (3)	
Commercial brand 2	116 (4)	

Results shown as mean (standard deviation).
EP: edible portion.

soaking after freezing showed being very effective, by managing to reduce the content to 6.19 mg/100 g EP, representing a loss of almost 93%. Both NC and DC applied after freezing also achieved, although to a lesser degree than soaking, significant reductions in the potassium content to values of 44.97 and 25.41 mg/100 g EP, respectively. The greatest losses were observed in frozen green beans treated by soaking prior to cooking, where virtually all present potassium was lost: values lower than 5 mg/100 g EP remained.

The potassium content of canned green beans is shown in Table 2. Values ranged between 78.70 and 125.76 mg/100 g EP. Greater variability was observed in the potassium content between brands of round green beans. On the other hand, the potassium content of canned flat green beans was similar to that obtained in fresh green beans after applying a soaking and subsequent cooking.

Chard

Table 3 shows the potassium contents (mg/100 g EP) and the percentage of loss due to each type of culinary process, for both chard leaf and stalk, fresh and frozen.

In fresh chard, the initial content of leaf and stalk is similar and high, however, greater losses were observed in the leaf regardless of the type of culinary treatment applied.

In the fresh chard leaf no significant differences were observed between applying DC, S + NC or S + DC, achieving contents lower than 85 mg/100 g EP. However, in the fresh stalk none of the treatments applied achieved significant reductions: the maximum losses were around 30% after applying S + NC or S + DC.

Freezing prior to cooking proved effective, as in the green beans, with increased losses for each type of treatment with respect to fresh produce, both in leaf and stalk. The application of soaking after freezing accounted for about 70% more loss than when applied on fresh produce: contents of 25.28 and 33.57 mg/100 g EP were reached in leaf and stalk, respectively, with losses even more marked if cooking was subsequently applied.

The little effectiveness in reducing potassium of the different treatments observed in fresh stalk was improved when subjected to freezing. It should be noted how the sole application of a DC managed to reduce the potassium content to values around 90 mg/100 g EP.

Unlike green beans, losses due to different treatments in industrially frozen chard leaves were higher than in home frozen chard. This is surely due to the type of cut used in industrial freezing being smaller than that employed in home freezing.

Table 3 – Potassium content and effect of different culinary processes in chard.

Culinary process	Fresh		Home frozen		Industrially frozen	
	mg/100 g	% loss	mg/100 g	% loss	mg/100 g	% loss
Results						
Raw	285.8 (13.1)	–	253.6 (9.0)	–	152.8 (6.0)	–
Soaking	185.7 (14.2)	20.1 (5.2)[a]	25.2 (1.0)	90.0 (0.4) [a]	2.2 (0.3)	97.8 (0.2) [a]
NC	123.7 (12.3)	47.0 (5.2)[b]	88.8 (3.3)	65.0 (1.3) [b]	28.0 (7.7)	76.0 (6.6) [b]
DC	78.9 (7.2)	66.3 (3.4)[c]	51.0 (5.6)	79.9 (2.2) [c]	9.7 (0.2)	90.2 (0.5) [c]
S + CN	84.3 (3.1)	58.5 (1.5) [c]	20.6 (0.5)	91.9 (0.2) [a]	0.8 (0.1)	99.2 (0.0) [a]
S + DC	66.7 (1.3)	67.0 (0.7) [c]	14.0 (0.4)	94.5 (0.1) [a]	0.7 (0.1)	99.3 (0.1) [a]
Stalk						
Raw	262.0 (22.5)	–	288.4 (6.0)	–		
Soaking	173.2 (6.6)	10.4 (4.0) [a]	33.6 (3.9)	79.2 (2.0) [a]		
NC	210.3 (2.2)	8.8 (2.2) [a]	110.0 (7.3)	47.0 (3.7) [b]		
DC	159.3 (2.2)	19.5 (0.9) [b]	88.9 (6.0)	51.1 (2.9) [b]		
S + CN	120.6 (5.1)	29.2 (1.4) [c]	17.1 (0.7)	89.0 (0.6) [c]		
S + DC	118.8 (7.4)	27.3 (1.1) [c]	15.1 (0.5)	89.9 (0.2) [c]		

Results shown as mean (standard deviation).
Mean values with different letters (a, b, c . . .) in the same column indicate significant differences ($p < 0.05$) in potassium loss among the different culinary processes.
NC: normal cooking; DC: double cooking; S + NC: soaking + normal cooking; S + DC: soaking + double cooking.

Table 4 – Potassium content in commercial mixed vegetables diced vegetable salad.

Product	Mixed vegetables		Diced vegetable salad	
	mg/100 g	% loss	mg/100 g	% loss
Commercial brand 1				
Raw	202 (16)	–	227 (15)	–
Cooked	126 (9)	26 (5)	82 (5)	50 (3)
Commercial brand 2				
Raw	156 (8)	–	163 (10)	–
Cooked	68 (3)	48 (4)	85 (4)	39 (4)
Commercial brand 3				
Raw	185 (14)	–	244 (12)	–
Cooked	121 (4)	22 (5)	105 (7)	44 (3)
Commercial brand 4				
Raw	211 (9)	–	244 (27)	–
Cooked	115 (13)	33 (13)	100 (10)	45 (3)

Results shown as mean (standard deviation).

The potassium content of the different types and brands of canned produce is seen in Table 2. The content was very variable between different brands. They were similar in leaf and stalk in canned whole chard. On the other hand, canned stalks also showed high potassium contents, but no higher than those found in some brands of whole chard.

Diced vegetable salad and mixed vegetables

The initial potassium contents and final contents after NC of frozen diced vegetable salad and mixed vegetable samples are shown in Table 4.

While in both types of product great initial variability in potassium content between different brands were observed, they were higher in diced vegetable salad than in mixed vegetables. However, the loss percentages were also higher in almost all cases in diced vegetable salad, which reached final maximum levels of 100 mg/100 g EP.

NC in mixed vegetables reduced the potassium content between 22 and 48%; the lowest content achieved was 68.13 mg/100 g EP.

Discussion

The initial potassium content found in samples of green beans and raw chard, both fresh and frozen, were lower than those provided by the Spanish composition tables,[13–15] whose data vary between 243 and 280 mg/100 g EP in green beans, and between 378 and 550 mg/100 g EP in chard. These differences in mineral composition may be due to many factors, such as the variety or the degree of development of the plant at its harvest, among others. However, none of these factors is usually specified in the tables. On the other hand, none of the queried tables showed values concerning the frozen diced vegetable salad, and in only one of them a value 130 mg/100 g EP was reached for the potassium content of frozen mixed vegetables.[13] This value was lower than that observed in this study, probably due to the variety of vegetables present in the mixed vegetables.

Regardless of the type of culinary process applied, in all samples tested a loss of potassium was observed to a greater or lesser degree. Soaking showed a positive effect in all cases. In previous work in tubers, soaking prior to cooking posed no loss of potassium,[11,12,16] while other studies in broccoli or carrots also showed a positive effect.[17] These contradictory results are probably due to structural differences between the foods under study, since the percentage of loss depends on several factors, such as the type of vegetable and its morphological structure.[18] This study has also observed how the structural differences between chard leaf and stalk may have been responsible for the different responses to the treatments studied, affecting their effectiveness.

There are few studies analyzing the efficacy of DC, and only applied to tubers. The results of our study show in many cases the lack of significant differences between NC and DC, both in green beans and chard, especially when applied after soaking. This is probably due to the high product/water ratio used, 100 g product/1.5 L water. However, it should be noted that one of the recommendations provided in the guidelines is cooking in plenty of water.

The results obtained in this study also confirm that freezing prior to cooking carries increased mineral loss,[18–20] probably due to cell damage caused by ice crystals. The results of this study have shown how prior freezing may be a useful strategy to reduce the potassium content to more than acceptable levels for people with CKD, as in the case of chard stalks, in which, only with that preprocessing, potassium levels of less than 100 mg/100 g EP have been achieved, values that were not e achieved with cooking fresh stalks. Soaking also showed to be much more effective when applied to frozen produce, with such low values that they did not require subsequent aqueous medium cooking. This would allow the possible application of other culinary preparations, such as sauteed, without lengthening the cooking time.

Conclusion

The results obtained in this study confirm that the processing and cooking of these vegetables in these working conditions allow reducing their potassium content to acceptable levels, which would allow their inclusion in the diet of patients with CKD. Furthermore, it has been observed that, in most cases studied, the sole application of a NC in frozen foods would be sufficient to achieve the desired potassium content loss. The results shown in this study are very positive, because they offer different possibilities for culinary preparation suitable for CKD, many of them with less preparation time than suggested in the recommendations of the dietary guidelines for CKD, which would allow adapting to patient preferences.

Funding

This work has been funded by: Federación Nacional ALCER [ALCER National Federation], Project OTRI 2011/0573, Grupos Consolidados de Investigación [Consolidated Research Groups], DGA (T41/2012 and A01/2012) and the Fondo Social Europeo [European Social Fund].

Conflicts of interest

The authors have no conflicts of interest to declare.

Acknowledgments

We would like to thank the Fundación Cuenca Villoro [Cuenca Villoro Foundation] for the scholarship granted to Montserrat Martinez-Pineda.

REFERENCES

1. Einhorn LM, Zhan M, Hsu VD, Walker LD, Moen MF, Seliger SL, et al. The frequency of hyperkalemia and its significance in chronic kidney disease. Arch Intern Med. 2009;169:1156–62.
2. Nazanin N, Kalantar-Zadeh K, Kovesdy CP, Murali SB, Bross R, Nissenson AR, et al. Dietary potassium intake and mortality in long-term hemodialysis patients. Am J Kidney Dis. 2010;56:338–47.
3. Saxena A. Nutritional problems in adult patients with chronic kidney disease: clinical queries. Nephrology. 2012;1:222–35.
4. Tonelli M, Pfeffer MA. Kidney disease and cardiovascular risk. Annu Rev Med. 2007;58:123–39.
5. Cano NJM, Aparicio M, Brunori G, Carrero JJ, Cianciaruso B, Fiaccadori E, et al. ESPEN guidelines on parenteral nutrition: adult renal failure. Clin Nutr. 2009;28:401–14.
6. Ruperto López M, Barril Cuadrado G, Lorenzo Sellares V. Guía de nutrición en enfermedad renal crónica avanzada (ERCA). Nefrologia. 2008:79–86.
7. García N, Errasti P, Muñoz M, Garcia M, Russolillo G. Insuficiencia renal. In: Muñoz M, Aranceta J, García-Jalón I, editors. Nutrición aplicada y dietoterapia. Segunda ed. Pamplona (España): EUNSA; 2004. p. 649–74.
8. Fernandez S, Conde N, Caverni A, Ochando A. La alimentación en la enfermedad renal. 1 ed. Madrid: Fundación Renal ALCER; 2009.
9. Russolillo G. Comer y beber en la enfermedad renal crónica avanzada. Baxter; 2002. Available at: http://www.insuficienciarenalcronica.com/alimen.swf [accessed 17.03.15].
10. Bower J. Cooking for restricted potassium diets in dietary treatment of renal patients. J Hum Nutr Diet. 1989;2:31–8.
11. Burrowes JD, Ramer NJ. Removal of potassium from tuberous root vegetables by leaching. J Ren Nutr. 2006 10;16:304–11.
12. Burrowes JD, Ramer NJ. Changes in potassium content of different potato varieties after cooking. J Ren Nutr. 2008;18:530–4.
13. Moreiras O, Carbajal A, Cabrera L, Cuadrado C. Tablas de composicion de alimentos. Guía práctica. 16.ª ed. Madrid: Pirámide; 2013.
14. Mataix Verdú FJ, Avilés Martínez JM. Tabla de composición de alimentos. 5.ª ed. Granada: Instituto de Nutrición y Tecnología de Alimentos, Universidad de Granada; 2009. p. 555.
15. Farran A, Zamora R, Cervera P. Tablas de composición de alimentos del CESNID. 2ª. ed. Barcelona: McGraw-Hill-Interamericana; 2004.
16. Bethke PC, Jansky SH. The effects of boiling and leaching on the content of potassium and other minerals in potatoes. J Food Sci. 2008;73:H80–5.
17. Jones WL. Demineralization of a wide variety of foods for the renal patient. J Ren Nutr. 2001;11:90–6.
18. Lisiewska Z, Słupski J, Kmiecik W, Gębczyński P. Availability of essential and trace elements in frozen leguminous vegetables prepared for consumption according to the method of pre-freezing processing. Food Chem. 2008;106:576–82.
19. Lisiewska Z, Gębczyński P, Bernaś E, Kmiecik W. Retention of mineral constituents in frozen leafy vegetables prepared for consumption. J Food Comp Anal. 2009;22:218–23.
20. Bernhardt S, Schlich E. Impact of different cooking methods on food quality: retention of lipophilic vitamins in fresh and frozen vegetables. J Food Eng. 2006;77:327–33.