Phosphorus and potassium content in foods for patients with chronic renal insufficiency

Teor de fósforo e potássio em alimentos para pacientes com insuficiência renal crônica

ABSTRACT

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The concentrations of phosphorus and potassium in different foods such as fruits, beverages, vegetables and sweets of interest for the dietary management of patients with renal failure were analyzed and compared with available data from the literature. For all foods analyzed, the values were different from those reported in the literature, except for one in the fruit group. Low phosphorus and low potassium diet was also detected and, when compared to the literature data, showed an even greater difference in potassium content. We conclude that it is important to elaborate and utilize data obtained in regional surveys considering the variability of nutrients depending on techniques of food preparation and crop conditions.

Keywords: foods; phosphorus; potassium; analysis; restricted diet; chronic renal disease; diet therapy management.

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RESUMEN

En este estudio se determinaron los tenores de fósforo y potasio en frutas, hortalizas, bebidas y dulces de interés en la dieto terapia de pacientes con insuficiencia renal crónica y se compararon con los datos de las tablas de composición de alimentos disponibles en nuestro medio. Los tenores determinados fueron diferentes de los encontrados en las tablas, en la mayoría de los casos. También fue analizada una dieta específica, recomendada para pacientes que necesitan restricción de fósforo y potasio. Los resultados del análisis de la dieta fueron más discrepantes que los obtenidos por consulta en las tablas de composición de alimento. Se concluye que es importante obtener datos regionales y que el uso de tablas extranjeras para la elaboración de dietas específicas puede resultar muchas veces en errores graves en relación al tenor de estos nutrientes.

Palabras clave: alimentos; fósforo; potasio; dietoterapia; insuficiencia renal crónica.

RESUMO

Os teores de fósforo e potássio em frutas, bebidas, legumes e doces de interesse no tratamento dietoterápico de pacientes com insuficiência renal crônica foram determinados e comparados com dados de diferentes tabelas disponíveis em nosso meio. Os valores obtidos foram, na maioria das vezes, diferentes dos encontrados nas tabelas. Também foi feita análise de uma dieta específica e recomendada para pacientes que precisam de uma restrição em fósforo e potássio. Os dados encontrados, para a dieta em si, foram ainda mais discrepantes do que os dados obtidos, por meio das tabelas consultadas. Pode-se concluir que é necessário e importante obter dados regionais e, que a utilização de tabelas internacionais para elaboração de cardápios específicos, muitas vezes, pode resultar em erros graves quanto ao teor destes nutrientes.

Palavras-chave: alimentos; fósforo; potássio; dietoterapia; insuficiência renal crônica.

INTRODUCTION

Minerals such as phosphorus and potassium play a fundamental role in metabolism and are essential for human nutrition. Protein-containing foods such as meat, fish, dairy products, legumes and whole cereals are good sources of these nutrients, as well as chocolate and oleaginous foods. Fruits and vegetables are also important sources of potassium (IBGE, 1996; PHILIPPI, 2002; ESTADOS UNIDOS, 1976-1986). On the other hand, controled ingestion of foods containing phosphorus and potassium among other nutrients becomes necessary with progressive loss of renal function, when phosphorus retention occurs and the ability to excrete potassium is reduced (KOPPLE, 1999). It has also been demonstrated that low phosphorus consumption may delay the progression of renal failure and prevent the occurrence of bone disease and calcification of the coronary arteries. The restriction of potassium-containing foods may also prevent the onset of cardiac arrhythmia (BARSOTTI *et al.,* 1984; LUMLERTGUL *et al.,* 1986).

Food mineral content is obtained from tables available in the literature, many of which, however, are incomplete and contradictory (LAJOLO e MENEZES, 1997; LAJOLO e VANNUCCHI, 1987; PHILIPPI *et al.,* 1995). To illustrate, depending on the source consulted, the phosphorus content of chocolate ranges from 142 (IBGE, 1996) to 216mg (UNITED STATES, 2002) and the amount of potassium in raw potatoes ranges from 421 (UNITED STATES, 2002) to 543mg (PHILIPPI, 2002). Similarly, it has been estimated that a phosphorus- and potassium-restricted diet offered to patients with renal failure provides approximately 700mg phosphorus and 1900mg potassium (UNITED STATES, 1976-1986). Moreover, it is also known that potassium is partially lost according to food preparation methods and cooking procedures, with consequent difficulties for the elaboration of an individualized diet therapy plan (CUPPARI *et al.,* 2004; JONES, 2001; LOUIS e DOLAN, 1970; TSALTAS, 1969).

Therefore the elaboration of menus that provide a greater variety of foods considering personal habits and preferences, together with diversity, regional availability and low cost, is important to guarantee an adequate supply of nutrients, to avoid monotony and thus to increase treatment compliance (SILVA *et al.,* 2000).

On this basis, and considering the importance of phosphorus and potassium for the nutritional therapy of patients with renal failure as well as the difficulty in obtaining reliable data on the content of foods, the first objective of the present study was to determine the concentrations of phosphorus and potassium in different foods for the dietary management of patients with chronic renal failure, and to compare them to already existing data. The second objective was to compare the concentrations of phosphorus and potassium in a low phosphorus and potassium diet used by the University Hospital of the School of Medicine of Ribeirão Preto, Universidade de São Paulo (HCFMRP-USP).

MATERIALS AND METHODS

All the natural and industrialized foods and the preparations selected for analysis were purchased by the Nutrition and Dietetics Service of HCFMRP, at open-air markets and

at supermarkets in the city of Ribeirão Preto, State of São Paulo, Brazil, during the year of 2001. Table 1 lists the fruit, beverages and different foods studied. The food and nutrient composition of low phosphorus and potassium diet is presented in Table 2. This selection was based on patient interest and clinical practice since HCFMRP attends patients from different regions of Brazil with varied habits and preferences (SILVA *et al.,* 2000).

Table 1 Comparison of phosphorus and potassium in different foods such as fruits, beverages, legumes and sweets of interest in the dietary management of patients with renal failure

	P (mg)[a]	*P (mg)*[b]	K (mg)[a]	*K (mg)*[b]
Fruit				
Assai Palm *(Euterpe oleracea L.)*	58	*79*	nd	*349*
Cajarana *(Cabralea cangerana Sald.)*	Nd	*15*	nd	*328*
Candied fruit	10	*4*	nd	*20*
Cashew nut *(Anacardium occidentalis L.)*	18	*14*	143	*31*
Common grapes *(Vitis vinifera L.)*	10	*175*	191	*76*
Common plum *(Prunus domestica L.)*	10	*17*	172	*59*
Copal *(Hymenaea spp.)*	24	*9*	nd	*1293*
Genipap *(Genipa americana L.)*	58	*26*	nd	*433*
German prune *(Prunus insititia)*	26	*21*	226	*40*
Imbú mango *(Spondias tuberosa Arr.Cam.)*	14	*31*	nd	*269*
Jackfruit *(Artocarpus integrifolia, Forst.)*	36	*18*	303	*168*
Japanese medlar *(Eryobotria japonica Lindl.)*	14	*9*	nd	*147*
Mangosteen *(Garcinia mangostana, Linneu.)*	20	*11*	nd	*150*
Mulberry *(Morus sp.)*	32	*28*	nd	*203*
Red globe grapes *(Vitis spp)*	Nd	*204*	nd	*152*
Red mombin *(Spondias purpurea L.)*	40	*16*	nd	*38*
Rose apple *(Eugenia jambos L.)*	13	*13*	nd	*42*
Sapodilla plum *(Achras zapota L.)*	6	*8*	193	*180*
Soursop *(Annona muricata L.)*	27	*32*	278	*363*
Sweetsop *(Annona squamosa L.)*	46	*380*	nd	*316*
Tamarind *(Tamarindus indica L.)*	113	*3*	628	*386*
West indian cherry *(Malpighia punicifolia)*	11	*19*	146	*49*
Beverages				
Alcohol-free beer	nd	*21*	nd	*25*
Anise tea[e] *(Pimpinella anisum)*	nd	*2*	nd	*16*
Artificial grenadine syrup	16	*0*	nd	*4*
Beer with alcohol	30	*18*	25	*31*
Coffee infusion[c] *(Coffea arábica, Linneu.)*	8	*5*	88	*71*
Cola-type soft drink	17	*21*	2	*1*
Diet guaraná *(Paullinia cupana)*	4	*1*	2	*1*
Guaraná-type soft drink *(Paullinia cupana)*	nd	*1*	nd	*3*
Mate tea[d] *(Ilex Paraguariensis, Linneu.)*	3	*2*	40	*10*
Orange soft drink *(Citrus sinesis)*	nd	*1*	nd	*19*
Tonic water	nd	*1*	nd	*1*

continued...

Table 1 (continued) Comparison of phosphorus and potassium in different foods such as fruits, beverages, legumes and sweets of interest in the dietary management of patients with renal failure

	P (mg)[a]	*P (mg)*[b]	K (mg)[a]	*K (mg)*[b]
Miscellaneous				
Black milk chocolate	231	*26*	384	*451*
Boiled hen egg	180	*199*	130	*80*
Caramel candy	119	*12*	123	*93*
Cooked bean broth *(Phaseolus vulgaris L.)*	11	*113*	34	*334*
Cooked beans *(Phaseolus vulgaris L.)*	114	*162*	338	*334*
Cooked beans and bean broth *(Phaseolus vulgaris L.)*	148	*129*	416	*292*
Crisp black milk chocolate	nd	*27*	nd	*365*
Eucalyptus flavored candy	nd	*12*	nd	*37*
Hard candy	nd	*20*	nd	*134*
Raw beans *(Phaseolus vulgaris L.)*	420	*403*	1038	*880*
Raw beans soaked 12hs at 28ºC *(Phaseolus vulgaris L.)*	nd	*241*	nd	*877*
Ultra High Temperature (UHT) whole milk	93	*108*	152	*126*
White chocolate	nd	*25*	nd	*406*
White chocolate with fruits	nd	*18*	nd	*389*
Yogurt flavored candy	nd	*11*	nd	*56*

[a-] phosphorus and potassium content obtained from food chemical composition tables;
[b-] mean phosphorus and potassium content obtained from the analyses performed;
[c-] 4% coffee infusion;
[d-] 2.5% tea infusion;
[e-] 2% tea infusion;
[nd-] not available.

All steps for the preparation and analysis of the material were carried out in duplicate. Twenty-six fruits were selected, washed, freed of seeds and separated into 2g raw aliquots; the solid, liquid and preparation processed foods were separated into 3g aliquots. Materials were then dried in an oven at 100ºC and reduced to ashes in a crucible at 400ºC, followed by ash extraction with 20% HNO_3, for phosphorus and potassium determination. Potassium was determined with a flame photometer (FC-280 CELM) and inorganic phosphorus was determined by the molybdenum blue method, with quantitative determination being performed with a spectrophotometer (Spectronic 20 Bausch Lomb). This method is valid and validated against another method of reference for determination of potassium in foods (SPITZER *et al.,* 1973). The method of phosphorus is also validated in an inter-laboratory study (PULLIAINEN e WALLIN, 1994).

The coefficient of variation of the biochemical parameters was always lower than 5%, tested by standard curves with five points in triplicate. The maximum variation accepted in the duplicate determination of foods was 10%. If variation exceeded that value, results were discarded and new determinations were performed.

The results obtained in the present study were compared with the following food data tables: 1) IBGE, 1996; 2) FRANCO, 1999; 3) PHILIPPI, 2002 and 4) UNITED STATES, 1976-1986.

The results are reported in milligrams per 100g of the original material, for convenience and uniformity with existing nutrition and dietetic tables.

Table 2 Composition of a low P and K diet used at HCFMRP**

	Home measurement/ Quantity	P (mg)[a]	*P (mg)[b]*	K (mg)[a]	*K (mg)[b]*
Breakfast					
3% fat milk	1 American cup - 150ml	143	*103*	232	*128*
Refined sugar	1 tablespoon - 15g	0	*0*	0.4	*23*
French bread	1/2 unit - 25g	21	*133*	22	*134*
Margarine	1 teaspoon - 5g	1	*2*	2	*3*
Morning snack					
Apple *(Malus sylvestris, Mill.)*	1 small unit - 100g	7	*3*	115	*93*
Sweet potato compote *(Convolvulus batata L.)*	2 tablespoons - 80g	13	*18*	185	*161*
Lunch					
Boiled rice *(Oryza sativa, Linneu.)*	4 tablespoons - 80g	22	*27*	22	*19*
Boiled chopped meat	1 1/2 tablespoon - 30g	45	*136*	73	*175*
Boiled carrot *(Daucus carota, Linneu.)*	5 tablespoons - 65g	19	*21*	147	*163*
Tomato *(Solanum lycopersicum)*	1/2 medium unit - 45g	10	*14*	93	*74*
Pineapple *(Ananas sativus)*	1 medium slice - 100g	7	*11*	113	*117*
Guava paste *(Psidium guajava L.)*	2 tablespoons - 80g	13	*29*	nd	*173*
Afternoon snack					
Pear *(Pyrus communis L.)*	1 small unit - 100g	11	*10*	125	*64*
Homemade pumpkin compote *(Cucurbita maxima, Dunch.)*	2 tablespoons - 80g	113	*7*	nd	*17*
Supper					
Pasta with tomato sauce	2 tablespoons - 60g	30	*18*	37	*72*
Baked chicken	1 medium leg - 40g	52	*146*	63	*193*
Manioc meal[f]	3 tablespoons - 48g	15	*27*	16	*185*
Boiled zucchini *(Cucurbita pepo L.)*	7 tablespoons - 98g	39	*6*	248	*93*
Lettuce *(Lactuca sativa L.)*	2 large leaves - 30g	7	*22*	79	*110*
Watermelon *(Citrullus vulgaris, Sohrad.)*	1 thin slice - 100g	9	*9*	116	*94*
Evening snack					
3% fat milk	1 American cup - 150ml	143	*103*	232	*128*
Refined sugar	1 tablespoon - 15g	0	*0*	0.4	*23*
French bread	1/2 unit - 25g	21	*133*	22	*134*
Margarine	1 teaspoon - 5g	1	*2*	2	*3*
Total					
Energy Kcal	1800	742	*828*	1945	*2101*
Protein - g	40				
High biological value proteins - g	30 (75%)				
Lipids - g	50				
Carbohydrates - g	300				

** vegetable oil for food preparation is included in the calculations;
[a]- phosphorus and potassium content obtained from food composition tables;
[b]- mean phosphorus and potassium content obtained from the analyses performed;
[f]- manioc flour preparation: 30g manioc flour dressed with 20g margarine and with seasonings added at will;
nd- not available.

RESULTS AND DISCUSSION

Comparison of phosphorus and potassium content of the selected foods is presented in Table 1. In the reference tables we could not find data about phosphorus content of 14 foods and potassium content of 26 foods. In addition, the values obtained in the present study were different for all foods as compared to the tables, except for phosphorus in rose apple fruit *(Eugenia jambos L.)*.

With respect to phosphorus, the greatest difference in the fruit group was detected for the sweetsop *(Annona squamosa L.)*, in the beverages group for the artificial grenadine syrup, and in the miscellaneous foods for the black milk chocolate. With respect to potassium, the greatest difference, in the fruit group, was found for the tamarind *(Tamarindus indica L.)*, mate tea *(Ilex Paraguariensis, Linneu.)* in the beverages group, and cooked bean broth in the miscellaneous foods.

The smallest difference in phosphorus content was found for sapodilla plums *(Achras zapota L.)* in the fruit group, mate tea *(Ilex Paraguariensis, Linneu.)* in the beverages group, and in Ultra High Temperature milk in the miscellaneous foods. The smallest difference in potassium was also found for sapodilla plums *(Achras zapota L.)* in the fruit group; cola-type and diet guarana soft drinks in the beverages group, and cooked beans in the miscellaneous foods.

Table 2 shows the comparison of a low protein diet (40g protein) with phosphorus and potassium restriction. The potassium content of guava paste and of pumpkin compote was not found in the tables consulted and the values obtained were different for all other foods, except for phosphorus in refined sugar and in watermelon *(Citrullus vulgaris, Sohrad.)*.

With respect to phosphorus, the greatest difference was found in the analysis of French bread and the smallest in the analysis of margarine and pears *(Pyrus communis L.)*; with respect to potassium, the greatest and smallest differences were found in manioc meal and in margarine, respectively. Comparison of the total nutrients of the diet analyzed with those obtained from the consulted table showed a greater difference in potassium content.

The nutrients composition of a given food may differ according to the database employed (whether Brazilian or international). In raw foods, as fruits and other vegetables, mineral content may vary from production to final consumption: agricultural practices, genetic varieties, soil and climate characteristics, storage and commercialization conditions also have to be considered. Industrial processing, at any level, is another source of differences (ALBINO *et al.,* 1999; BARROS *et al.,* 1980; IBGE, 1986; LAJOLO e VANNUCCHI, 1987; PENNINGTON *et al.,* 1995; PHILIPPI *et al.,* 1995; TAHVONEM, 1993).

Our results differed from 4.5 to 20% from those of CUPPARI *et al.* (2004) regarding potassium content in raw apple, beans, cooked carrot and raw pineapple. Differences were higher when our results were compared to those of TSALTAS (1969) regarding potassium content of tomato (74mg and 240mg, respectively) and cooked carrot (230mg and 163mg, respectively).

Therefore it is important to measure actual food composition, instead of entirely relying in tables of food composition to plan a phosphorus/potassium-restricted diet for kidney failure patients. Errors may become cumulative and patient control on that particular item may become difficult or impossible.

CONCLUSIONS

Dietitians who regularly use food composition data to plan and evaluate low phosphorus and potassium diets need to obtain safe data about the concentration of these specific nutrients. The United Nations Organization for Food and Agriculture recommends the elaboration of composition tables for foods locally produced and consumed (HARDISSON *et al.,* 2001). Since Brazil is a country of large dimensions with different climatic and cultural conditions, which can influence the nutritive value of foods, it is necessary to elaborate and use Brazilian research instruments that consider the variability of nutrients. In addition, phosphorus and potassium content of the foods hereby analyzed may be used as a guide for professionals working with low phosphorus and potassium diets, when other data are not available.

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