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Original article

Most consumed processed foods by patients on hemodialysis: Alert for phosphate-containing additives and the phosphate-to-protein ratio

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SUMMARY

Background and aims: Hyperphosphatemia is common in patients with chronic kidney disease (CKD) stages IV and V because of decreased phosphorus excretion. Phosphatemia is closely related to dietary intake. Thus, a better understanding of sources of dietary phosphate consumption, absorption and restriction, particularly inorganic phosphate found in food additives, is key to prevent consequences of this complication. Our aims were to investigate the most commonly consumed processed foods by patients with CKD on hemodialysis, to analyze phosphate and protein content of these foods using chemical analysis and to compare these processed foods with fresh foods.

Methods: We performed a cross-sectional descriptive analytical study using food frequency questionnaires to rank the most consumed industrialized foods and beverages. Total phosphate content was determined by metavanadate colorimetry, and nitrogen content was determined by the Kjeldahl method. Protein amounts were estimated from nitrogen content. The phosphate-to-protein ratio (mg/g) was then calculated. Processed meat protein and phosphate content were compared with the nutritional composition of fresh foods using the Brazilian Food Composition Table. Phosphate measurement results were compared with data from the Food Composition Table – Support for Nutritional Decisions. An α level of 5% was considered significant.

Results: Food frequency questionnaires were performed on 100 patients (mean age, 59 $\pm$ 14 years; 57% male). Phosphate additives were mentioned on 70% of the product labels analyzed. Proteins with phosphate-containing additives provided approximately twice as much phosphate per gram of protein compared with that of fresh foods ($p < 0.0001$).

Conclusions: Protein and phosphate content of processed foods are higher than those of fresh foods, as well as phosphate-to-protein ratio. A better understanding of phosphate content in foods, particularly processed foods, may contribute to better control of phosphatemia in patients with CKD.

1. Introduction

Progressive deterioration of kidney function in chronic kidney disease (CKD) leads to retention of many substances, including phosphate [1]. In advanced CKD, urinary phosphate excretion is severely limited. Thus, dietary absorption is a critical determinant of bone mineral disorder development, emphasizing the importance of phosphate dietary intake restriction [2]. However, significant phosphate sources are also sources of protein [3]. Increasing protein intake is important for preventing malnutrition, which is a leading cause of morbidity and mortality in this population [4,5].

Sullivan et al. [6] compared two educational strategies regarding phosphate restriction in a randomized controlled trial in patients on maintenance hemodialysis. Reducing phosphate additives was more effective at decreasing phosphatemia than the standard

Abbreviations: CKD, chronic kidney disease; FFQ, food frequency questionnaires; HD, hemodialysis.

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strategy of eliminating known sources of phosphate, demonstrating the impact of additive intake on phosphatemia control.

Unlike plant phosphates, phosphates from additives are readily absorbed because of their inorganic properties. Plant phosphates are in the form of chelates and phytates, which are poorly absorbed by the human gastrointestinal tract [7]. It is noteworthy that the type of food source is as important as phosphate content [8]. Limiting dietary phosphate intake by reducing inorganic sources may be an effective approach to reduce serum phosphate levels.

Thus, additional knowledge regarding phosphate and protein content will allow more effective nutritional counseling for patients with CKD. Few studies and data sources disclose phosphate quantities in processed foods [9] and beverages [10]. Therefore, the most commonly consumed processed foods by patients with CKD on hemodialysis (HD) were investigated. The phosphate and protein content were chemically analyzed and compared with those of fresh foods.

2. Materials and methods

This was a cross-sectional descriptive analytical study, in which food frequency questionnaires (FFQ) were performed on patients on maintenance HD from the Hospital of Faculdade de Medicina de Botucatu, Univ Estadual Paulista (UNESP) between March and May 2013. Patients older than 18 years of age and on HD for at least 90 days were included. Patients who were unable to feed orally during the last 3 months or those who had clinical complications, such as acute infectious processes and surgeries, hospitalizations or situations that altered appetite for more than a week were excluded.

Processed foods were identified from the food frequency data, and phosphate and nitrogen content were quantified. The nitrogen measurement was used to estimate the amount of protein and, thereby, calculate the phosphate-to-protein ratio of each food. The nutritional composition of fresh foods was obtained from the Brazilian Food Composition Table [11] and compared with that of processed meat products. Phosphate measurement results were compared with data from the Food Composition Table – Support for Nutritional Decisions [12].

The study protocol was approved by the Research Ethics Committee of Faculdade de Medicina de Botucatu, UNESP.

2.1. Sample characterization

Demographical (age, gender, and educational level), clinical (cause of end-stage renal disease and diabetes mellitus), nutritional (weight, height and body mass index [BMI], energy and protein intakes analyzed by three-day diet recalls, and phosphate intake by FFQ), and biochemical data were collected from medical records.

Participants were instructed to register everything eaten during three days, and to not change their usual diet. Energy and protein intake estimates were analyzed using the software "Dietpro 5i Profissional". Frequencies of consumption of listed foods and its portion sizes were obtained from FFQ to assess the usual habits at the previous month. From these frequencies, a score (times a month the patient consumed each food) was created with the objective to estimate the phosphate daily intake, considering the chemical analysis.

FFQ were performed by the same professional to identify the 20 most consumed processed foods and beverages. Identified foods were classified as processed meat products, breaded meat, canned fish or dairy.

2.2. Phosphate and nitrogen content determination in processed foods

Chemical analyses were conducted to measure phosphate and nitrogen content in selected foods. The amount of protein was estimated from obtained nitrogen values.

Three brands of each selected food, according to market price (high, intermediate and low cost), were analyzed in duplicate. The products were purchased in local supermarkets. Chemical composition was performed at the Faculdade de Ciências Agronômicas, Campus Botucatu, UNESP. Phosphorus-containing additives were considered to be present if they were included in the ingredients list of at least one of the three product brands. Sample preparation and nitrogen and phosphate determinations were performed according to the international standard of the Association of Analytical Communities [13].

To determine the total phosphate content in solid products, a 100-g portion of each item was packaged in sealed plastic bags, coded and transported to the laboratory for analysis in appropriate containers. Laboratory technicians were blinded to nutritional information on food labels. Coded samples were ground using stainless steel blades. Samples were then dried to a constant weight in an oven with forced air circulation at 100 °C, cooled, packed and labeled in paper packages. Samples of 500 mg of solid food or an aliquot of the liquid were placed in a digestion tube with a nitric perchloric acid mixture at a ratio of 4:1. The digestion was performed on a digester block at 225 °C until all carbon was consumed. Phosphate content was measured by metavanadate colorimetry [14] and expressed as g/100 g of solid product or as g/100 ml of liquid product.

To determine nitrogen content, the Kjeldahl method [13] was used. This method is based on a digestive process in which organic matter is destroyed with sulfuric acid and copper II sulfate as a catalyst from the same dried sample. The digestion temperature was gradually adjusted to reach 420 °C. Organic nitrogen was converted to ammonia and distilled in the presence of sodium hydroxide. Distilled ammonia was collected in a diluted boric acid solution and titrated with 0.1 N hydrochloric acid. Protein content was calculated from total nitrogen content using a protein-to-nitrogen conversion factor of 6.25 [15].

2.3. The phosphate-to-protein ratio

To calculate the phosphate-to-protein ratio (mg/g), phosphate determination was expressed in mg per 100 g, and protein was expressed in g per 100 g.

2.4. Statistical analysis

Patient characteristics were described as percentages or mean ± standard deviation. Food consumption from FFQ was calculated based on daily frequency. The Wilcoxon test was used to compare phosphorus and protein content from processed meat products with that of fresh foods. A Student's t-test was used to compare measured phosphate amounts with the Food Composition Table – Support for Nutritional Decisions. An α level of 5% was considered significant. Analyses were performed by SAS for Windows, v.9.3 (Microsoft® Windows®, USA).

3. Results

Demographical, clinical, nutritional, and biochemical data of 100 patients who answered the FFQ are shown on Table 1.

The phosphate and protein determinations (n = 20), the phosphate-to-protein ratios and the presence of additives on labels