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Effect of Leaching on the Potassium Content of Foods for CKD Patients

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ABSTRACT

This study aimed to assess the potassium content in various food groups before and after the leaching process. A premix was formulated using locally available and affordable foods to prevent hyperkalemia in CKD patients. Food samples, including Bajra, jowar, ragi, black gram dal, green gram dal, red gram dal, agathi leaves, amaranth leaves, drumstick, potato, radish, papaya, banana, raisins, and almonds, were analyzed for potassium content. Significant differences were found before and after leaching ($p < 0.01$). Two premix variations were formulated and analyzed. Variation I contained powdered bajra, jowar, black gram dal, red gram dal (20g each), amaranth leaves (10g), almonds (5g), and black raisins (5g). Variation II included powdered bajra, jowar (15g each), ragi (10g), black gram dal, red gram dal (15g each), green gram dal (10g), drumstick, agathi leaves (10g each), almonds, and black raisins (5g each). Both premixes showed significant results ($p < 0.01$ for Variation I, $p < 0.05$ for Variation II). This study provides valuable insights into potassium content and premix formulation for preventing hyperkalemia in CKD patients.

Keywords: CKD, ESRD; Hyperkalemia; Leaching

Abbreviations: BP: Blood Pressure; CKD: Chronic Kidney Disease; ESRD: End Stage Renal Disease; EGFR: Estimated Glomerular Filtration Rate; TRV: Tuberous Root Vegetables

Introduction

Kidneys play a major role in filtering blood to maintain fluid and electrolyte balance, removing waste from the body, releasing hormones to control blood pressure (BP) and stimulating the red blood cell production which can ultimately reduce the incidence of CVD and anemia in CKD, and activating vitamin D to maintain bone health. (Simon DS Fraser and Tom Blakeman, 2017) chronic kidney disease (CKD) is defined as the presence of kidney damage or an estimated glomerular filtration rate (eGFR) less than 60 ml/min, which is persisting for 3 months or more, irrespective of the cause. [1]. One common and major life - threatening complication of CKD is hyperkalemia which can lead to cardiac arrhythmia and sometime block rennin- angiotensin system which disturbs the normal regulation of blood pressure and fluid balance. It is common in patients with CKD, those who are undergoing dialysis and ESRD. The intake of Potassium must be limited for the patients with chronic kidney disease and End Stage Renal Disease (ESRD) to 1500–2000 mg/day, thereby preventing the complications like hyperkalemia. Hyperkalemia can be classified according to serum potassium into mild (5.5–6.5 mmol/l), moderate (6.5–7.5 mmol/l) and severe (>7.5 mmol/l) hyperkalemia. (Anja Lehnhardt and Markus J. Kemper, 2010) Hyperkalemia is basically an electrolyte disturbance that occurs when renal potassium excretion is limited by reductions in glomerular filtration rate, tubular flow, distal sodium delivery or the expression of aldosterone-sensitive ion transporters in the distal nephron [2].

The major risk factors include with lower estimated glomerular filtration rate (eGFR) and use of renin-angiotensin-aldosterone system inhibitors. It is still a therapeutic challenge to treat a patient with CKD and chronic HK, because the process of detecting it would cause to progress CKD faster. A study has shown that the usage of K binder drugs was helpful in the treatment of patients with hyperkalemia. (David K Packham, Henrik S Rasmussen, et al, 2014) There-

fore, restricting potassium means to reduce the intake of foods rich in potassium such as whole grains, common fruits and vegetables. However, the diet becomes more monotonous and the other minerals in the foods with potassium are not consumed as well. As a common practice, Potassium is an important mineral and the most abundant intercellular cation for the physiological functions of the human body including the fluid balances, chemical reactions, and muscle contractions. Current dietary guidelines recommended potassium intake of 3,400 mg/d in adult men and 2,600 mg/d in adult women with normal kidney function [3].

The Intracellular potassium concentration is 5.9 g/L, with the remainder present in the extracellular fluid. The extracellular fluid concentration of potassium is maintained at a level of 3.5–5.5 mmol/L (137–215 mg/L). The potassium ingested through diet is mainly excreted through urine (80-90%). The remaining (10-20%) is excreted through sweat, faeces. The potassium is mostly filtered through the kidney glomerulus is reabsorbed throughout the proximal kidney tubules and the loop of Henle. High extracellular potassium levels stimulate the release of aldosterone, which then promotes increased distal tubular secretion of potassium into the urine. The increase in the levels of potassium is a concern for CKD patients [4]. leaching is done to remove the potassium from the food. Leaching is a process of soaking raw or frozen vegetables in water for at least two hours before cooking to «pull» some of the potassium out of the food and into the water [5]. The research work on raw Tuberous Root Vegetables (TRV) is done to determine the amount of potassium by leaching varieties of TRV like black yam, white yam, yellow yam, yampi, malanga, red yautia by applying different soaking time and cooking methods.

The final potassium content was measured using Atomic Absorption Spectroscopy. It was found that the double cooking method (boil, rinse, boil) leached more potassium than the other methods (soaking and cooking) [6]. The research work on the vegetables "Potato" and "Yam" were subjected to leaching and then cooking with different kinds of water like bore well water, metro water and mineral water. The potassium content of the cooked food before and after leaching was measured with various types of water used and the cooking methods (including pressure cooking and microwave cooking). The potassium content was measured using absorption spectrophotometry. The potassium analysis of the water sample in the pressure-cooked food after leaching was reduced [7]. The primary objective of this study is to determine analytically the amount of potassium in food groups and to estimate the amount of potassium that can be leached from a particular food group by soaking in water and to formulate a premix using those experimental foods included in this study to prevent hyperkalemia in patients with CKD.

Materials and Methods

The foods that are locally available in the market which are high in potassium, easily affordable and nutritious like bajra, Jowar, Ragi, Black gram dhal, Green gram dhal, Red gram dhal, Agathi leaves, Amarnath leaves, Drumstick, Potato, Radish, Banana, Papaya, Raisins and Almonds were included in this study. The food samples were diced into 1 cm cubes and each sample was weighed using a standard weighing scale and 100 grams of each sample was taken. The initial potassium content of each food sample was measured by flame photometry method of nutrient analysis. Then the following food samples are each soaked into water for 4 hours until the potassium is leached into the water. The potassium content of each food sample after leaching was measured by flame photometry method of nutrient analysis.

For the premix preparation the ingredients of Variation- I with powdered bajra, jowar, black gram dal, red gram dal (20 grams each), amaranth leaves (10 grams), almonds (5 grams) and black raisins (5 grams) and Variation II with powdered bajra, jowar (15 grams each), ragi (10 grams), black gram dal, red gram dal (15 grams each), green gram dal (10 grams), drumstick and agathi leaves (10 grams), almonds, black raisins (5 grams each) were weighed by standard weighing scale and underwent leaching process i.e., soaking in order to reduce the potassium content. After the leaching process, the ingredients were sun dried, roasted and ground to a fine powder [8-11].

Formulation of a Premix

A premix was formulated from the selected food samples to prevent hyperkalemia in patients with CKD in two variants. Variation- I with 100 grams each of bajra, jowar, black gram dal, red gram dal, amaranth leaves, almonds, black raisins and Variation II with 100 grams each of bajra, jowar, ragi, black gram dal, green gram dal, red gram dal, agathi leaves, amaranth leaves, almonds, black raisins and were given for nutrient analysis of potassium. The selected ingredients were subjected to cleaning and thoroughly checked. All the ingredients underwent the leaching process and were roasted for flavour and aroma. After roasting they were ground to a fine powder for the premix. This premix can be used to make various formulations and can be included as a part of daily routine diet of CKD patients.

Nutrient Analysis

The following food samples were sent to the lab for nutrient analysis. The initial potassium content of each food sample were measured. The food samples were soaked in water for 4 hours and the potassium content after leaching was measured. The potassium content of the ingredients on the formulated premix of two variants were measured at first and then they were leached in water to reduce the potassium content. After leaching, they are sun dried, roasted, ground to a fine powder and the potassium content was measured.

Inferential Analysis

In analysis, mean score, standard deviation and t- value and p-value was done to assess the level of significance of the food samples and the premix.

Results and Discussion

Nutrient analysis of the following food samples of bajra, jowar, ragi, black gram dal, red gram dal, green gram dal, drumstick, agathi leaves, amaranth leaves, potato, radish, papaya, banana, almonds, black raisins was done before and after leaching of 4 hours in water and are compared with Indian Food Composition Tables (IFCT) book values. The potassium content of the premix before and after leaching was also determined. Table 1 represents the nutrient analysis of potassium in the selected food groups before and after the leaching process and is compared with IFCT (2017) book values. The potassium content in red gram dal is reduced up to 83% resulting in the major loss among all the selected food samples. 70% loss in seen in black gram dal and black raisins. 60% loss is found in green gram dal and 20- 50% reduction was observed in bajra, jowar, ragi, agathi leaves, amaranth leaves, drumstick, potato, radish, banana, papaya and almonds. The potassium content of all the samples with ICFT values and before/after leaching were summarized and plotted in the (Figures 1 & 2) we can observe that, the potassium was leached heavily (≥ 75%) in black gram dhal and red gram dhal, while medium leaching of potassium (≥ 30% and ≤ 75%) happens in bajra, ragi, green gram dhal, agathi leaves, amaranth leaves, potato, papaya and almonds. The leaching is low (< 30%) for the samples jowar, drumstick, radish and banana.

Table 1: Mean, Standard deviation of the selected food samples before and after leaching process compared with IFCT (2017) values.

Samples	Mean ± Standard Deviation (IFCT VALUES)	Mean ± Standard Deviation (Before leaching)	% Difference of (K^+) between IFCT and before leaching	Mean ± Standard Deviation (After leaching)	% of (K^+) Leached
Bajra	365 ± 18	239.67 ± 4.726	-35%	152.00 ± 2.000	36.5 %
Jowar	328 ± 25.1	216.67 ± 3.055	-34%	173.33 ± 1.528	20%
Ragi	443±59.6	290.33 ± 3.512	-65%	130.00± 3.606	55.2%
Black gram dal	1157±38.6	981.67 ± 5.508	-15.2%	236.67 ± 6.110	75.8%
Red gram dal	1395±118	1917.67± 7.095	27.3%	308.67± 7.572	83.9%
Green gram dal	1177±74.3	872.33 ± 4.041	29.9%	315.67 ± 3.512	63.8%
Agathi leaves	674	189.33 ± 3.055	- 72%	124.00 ± 4.000	34.5%
Amaranth leaves	572±152	578.33 ± 2.517	1.1%	367.67 ± 2.517	36.4%
Drumstick	419±76.4	311. 00 ± 9.644	-25.8%	234.33 ± 3.215	24.6%
Potato	474	197.00 ± 3.606	-58.5%	112.33 ± 6.807	42.9%
Radish	287	343.00 ± 5.000	16.4%	253.67 ± 5.508	26%
Banana	362	353.67 ± 4.041	-2.4%	315.67 ± 3.512	10.7%
Papaya	173±12.4	206.67 ± 7.638	19.4%	113.67 ± 5.132	44.9%
Almonds	699±43.4	683.67± 5.508	-2.2%	370.67 ± 7.371	45.7%
Black raisins	1105±145	904.00 ± 4.000	-18.2%	250.00 ± 5.292	72.3%

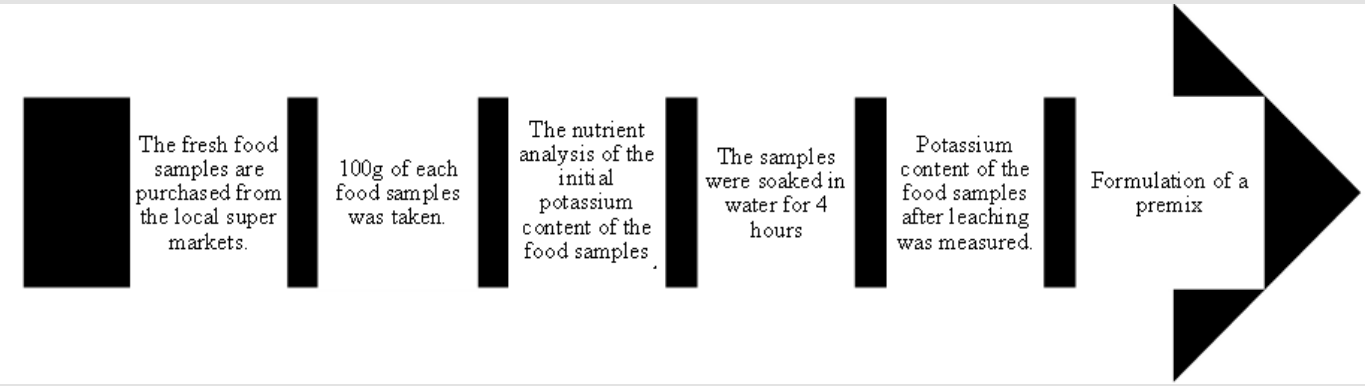

Figure 1: Flow of work

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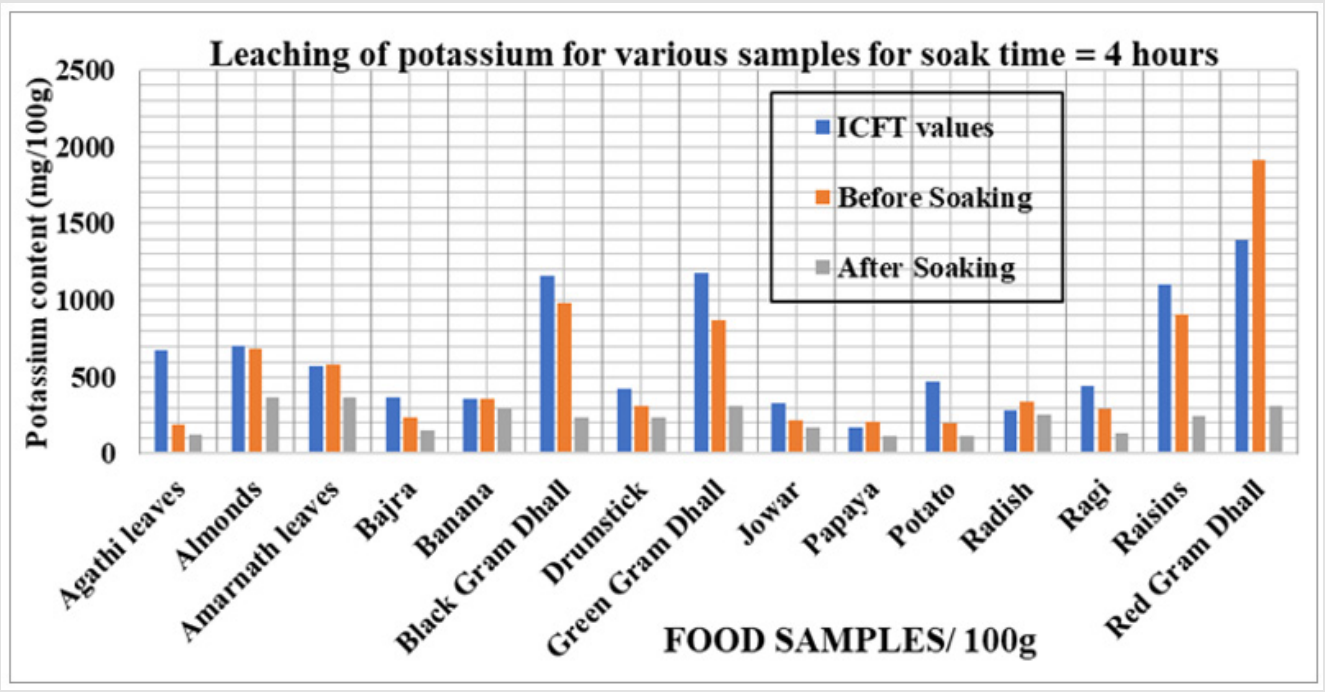

Figure 2: Comparison of the potassium values before/after leaching with IFCT book values in all samples [10].

Table 2 explains the potassium content of the premix of (Variation-I) including bajra, black gram dhal, red gram dhal, jowar, amaranth leaves, almonds and black raisins before and after the leaching process. The mean and standard deviation of the premix before and after leaching ranges from 751 ± 605.4 to 249.7 ± 78.3 after the leaching process. Table 3 explains the potassium content of the premix of (Variation- II) including bajra, jowar, ragi, black gram dhal, red gram dhal, green gram dhal, agathi leaves, drumstick, almonds and black raisins before and after leaching process. The mean and standard deviation of the premix before and after leaching ranges from 66.7± 543.4 to 232.8 ± 86.4. It shows that there was a reduction of potassium content after the leaching process. Table 4 shows the level of significance of all the food samples. From the obtained results it was observed that the $p < 0.01$ for all the food samples. Therefore, all the food samples are significant. Table 5 shows the level of significance of the premix of Variation- I. It was observed that the result of the premix of Variation- I was significant ($p< 0.01$). Table 6 shows the level of significance of the premix of Variation- II. It was observed that the result of the premix of Variation- II was significant ($p< 0.05$)

Table 2.

Samples	Potassium values (mg/100g)	
	Before leaching	After leaching
BAJRA	238	152
JOWAR	214	172
BLACK GRAM DAL	982	242
RED GRAM DAL	1924	314
AMARANTH LEAVES	314	233
ALMONDS	684	379
RAISINS	904	256
	751.4 ± 605.4	249.7 ± 78.3

Table 3: Potassium content of the premix.

Samples	Potassium values (mg/100g)	
	Before leaching	After leaching
BAJRA	238	152
JOWAR	214	172
RAGI	294	133
BLACK GRAM DAL	982	242
RED GRAM DAL	1924	314
GREEN GRAM DAL	873	319
AGATHI LEAVES	190	128
DRUMSTICK	314	233
ALMONDS	684	379
BLACK RAISINS	904	256
	751.4 ± 605.4	249.7 ± 78.3

Table 4: Mean & Standard deviation and the level of significance on the potassium of the selected food samples before and after leaching process.

Samples	Mean ± Std. Deviation (Before leaching)	Mean ± Std. Deviation (After leaching)	t-value
BAJRA	239.67± 4.726	152.00 ± 2.000	52.600
JOWAR	216.67 ± 3.055	173.33 ± 1.528	49.135
RAGI	290.33 ± 3.512	130.00± 3.606	240.500
BLACK GRAM DAL	981.67 ± 5.508	236.67 ± 6.110	281.481
RED GRAM DAL	1917.67± 7.095	308.67± 7.572	1609.000
GREEN GRAM DAL	872.33 ± 4.041	315.67 ± 3.512	315.600
AGATHI LEAVES	189.33 ± 3.055	124.00 ± 4.000	37.041
AMARANTH LEAVES	578.33 ± 2.517	367.67 ± 2.517	72.495
DRUMSTICK	311. 00 ± 9.644	234.33 ± 3.215	17.537
POTATO	197.00 ± 3.606	112.33 ± 6.807	35.223
RADISH	343.00 ± 5.000	253.67 ± 5.508	268.000
BANANA	353.67 ± 4.041	315.67 ± 3.512	12.771
PAPAYA	206.67 ± 7.638	113.67 ± 5.132	23.250
RAISINS	904.00 ± 4.000	250.00 ± 5.292	157.086
ALMONDS	683.67± 5.508	370.67 ± 7.371	55.045

Table 5: Mean, Standard deviation and level of significance on potassium content of the premix (Variation- i) before and after leaching

Potassium value (K^+)	Mean ± Standard deviation (Before leaching)	Mean ± Standard deviation (After leaching)	t-test	p-value
	751.4 ± 605.4	249.7± 78.3	2.44	0.50*

Table 6: Mean, Standard deviation and level of significance on potassium content of the premix (variation ii) before and after leaching process.

Potassium value (K^+)	Mean± Standard deviation (Before leaching)	Mean±Standard deviation (After leaching)	t-test	p-value
	661.7 ± 543.4	232.8 ± 86.4	2.26	0.02*

Conclusion

From the above study, it can be concluded that leaching has an enormous effect on the potassium content of the food. Leaching reduces the potassium content and increases its bioavailability to include the selected food samples as a part of the diet pattern to reduce the risk of hyperkalemia in CKD patients. The food samples that were leached showed promising results and the two variants of premixes prepared using the same leaching method showed better results. The potassium content after leaching is within the permissible levels and thus patients with renal disease need not exclude those food groups from their diet pattern. The study encompassed all food groups and accounted for the inclusion of high potassium foods even after the process of leaching. Balancing and monitoring portion sizes and incorporating a diverse range of foods are key approaches to meet the necessary requirements.

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