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Development of a Green Banana-based Food and the Effects of Its Consumption on the Intestinal Transit of Hemodialysis Patients

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Abstract **Introduction:** Hemodialysis patients are generally subjected to water and food restrictions imposed by treatment, which hamper intestinal transit. The aim of the present study was to develop a green banana food and evaluate its effects on the intestinal functioning of these individuals. **Methods:** Fifty-three hemodialysis patients were randomized into two groups: those who consumed 50.0 g of green banana cake, and the placebo group, whose recipe was prepared using ripe bananas. Before and after a two-month cake consumption period, the intestinal function was evaluated according to Rome III Criteria and the Bristol Stool Form Scale. A dietary habit assessment was also conducted to estimate fiber intake. **Results:** After the intervention, the constipation percentages decreased from 23.1% to 5.1% in the green banana group and from 15.4% to 7.7% in the placebo group. Improvements in stool consistency were especially noteworthy in the green banana group. The participants' fiber intake did not undergo significant changes during the study. **Conclusions:** The study sample showed a high prevalence of intestinal constipation. It was not possible to claim that the green banana was exclusively able to improve intestinal transit. It is believed that higher amounts of resistant starch may lead to statistically significant differences in the results.

Keywords: *constipation, hemodialysis, banana, musa, resistant starch*

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1. Introduction

Chronic kidney disease (CKD) is characterized by the slow, progressive, and irreversible loss of renal function. As the condition progresses, continuous treatment to replace renal function, such as hemodialysis (HD), becomes necessary [1].

Hemodialysis patients are usually required to limit water intake and restrict the consumption of specific nutrients, such as potassium, due to the difficulty in removing excess fluids and substances in the blood. These changes in dietary patterns, combined with physical inactivity and the use of medications that interfere with bowel function, render intestinal constipation a frequent complaint in this population [2].

The World Gastroenterology Organization defines intestinal constipation as a disorder characterized by the persistent difficulty to evacuate or the sensation of incomplete evacuation and/or decreased bowel movements [3]. A study conducted in 2008 in Brazil by Anzuategui *et al*. verified that 33.5% of HD patients exhibited intestinal malfunction, and the constipation rates were significantly higher in those who consumed fewer fibers and liquids and did not exercise [4].

In order to improve intestinal function in patients with CKD, researchers have investigated the use of prebiotic compounds, which are selectively fermented ingredients that allow specific modifications in the composition and/or activity of the intestinal flora, thus conferring health benefits to the host [5,6]. Previous studies highlight the similar effects of some substances present in foods, although they are not yet considered as prebiotics. An example of these compounds is resistant starch, which, since it is not absorbed, reaches the colon and is fermented by intestinal bacteria, enabling intestinal functioning [7,8]. Data indicate a daily consumption of approximately 5.0 grams of resistant starch by the North American population, which is below the recommendations of 6.0 g per meal, or around 20.0 g per day [9].

Resistant starch is known to be found in several foods, one of which is the green banana. Given the fruit has not yet reached its maturation stage, it retains significant concentrations of this element [10].

Green bananas are widely consumed in food preparations in various regions of the world, such as in maize and beef stews in Ecuador, in mixtures of indigenous Peruvian

foods, and even cut into slices and fried in Cuba [11]. Some researchers attribute the versatility of green bananas to the fact that the fruit does not promote flavor changes in the recipes in which it is added, as well as its low cost and ease in obtaining [11,12].

The green banana has been recently utilized in Brazilian food, in cooked or flour form [13]. Several studies have used it in the elaboration of products, such as cookies and breads, in order to enhance nutritional values, to substitute poorly-tolerated ingredients, or even to confer prebiotic properties [13,14].

Considering the discussed information, the primary aim of the present study was to develop a green banana-based food and evaluate its effects on the intestinal transit of HD patients.

2. Materials and Methods

The study was performed with 53 patients undergoing treatment at the Dialysis Unit of the Clinical Hospital of the Ribeirão Preto School of Medicine, at the University of São Paulo (HCFMRP-USP), and was approved by the institution's Research Ethics Committee according to Process number 994.599, on February 27, 2015.

The inclusion criteria consisted of: ages above 18 years and HD duration greater than six months. In turn, the exclusion criteria comprised: alcohol abuse prior to the study, recent blood transfusion, laxative medication use, and the presence of neoplasias, human immunodeficiency virus (HIV), or intestinal diseases.

The following data were obtained or confirmed using the medical records of the patients who met the above criteria: age, gender, HD duration, medications used during the study, underlying diseases, and routine biochemical examinations. After sample selection, the patients were allocated into two groups: one which consumed 50.0 g of green banana cake, and the placebo group, in which the preparation used ripe bananas. The following ingredients were used in food preparation: wheat flour, egg, sunflower oil, sucralose sweetener combined with maltodextrin and acesulfame potassium, brown sugar, and chemical yeast. The nutritional information of the final food was estimated from the employed ingredients, using the Brazilian Table of Food Composition - TACO [15]. The percentage of resistant starch present in the green bananas was 62%, as indicated by Lii, Chang, and Young (1982) [16].

The cakes were supplied during the snacking period of the dialysis sessions over a period of 2 months, in which the patient was given one portion of cake and received a second to be consumed the following day, when dialysis did not take place.

Prior to and after the intervention, the description of intestinal function was conducted using tools available in the World Gastroenterology Organization Guide: Rome III Criteria and the Bristol Stool Form Scale [3]. The dietary evaluation was also carried out by analyzing the 3-day food registry to assess the food habits of the patients and their possible interference in intestinal transit. After the food logs were collected, the nutritional information was calculated using version 5.i of the Diet Pro software.

Statistical analysis of the data was performed using the Spearman Correlation Coefficient and the non-parametric Wilcoxon and Kruskal-Wallis tests. The level of significance was 5% ($p < 0.05$).

3. Results

After the months in which the green banana-based recipe was developed and tested, a cake was obtained, and the nutritional values of its individual portions (approximately 50.0 g) were estimated (Table 1).

Table 1. Nutritional information estimation based on one portion of green banana cake

Quantity per portion (50.0 g)	
Energetic value	88.5 kcal = 370 kJ
Carbohydrates	9.0 g
Proteins	2.0 g
Total fat	5.0 g
Saturated fat	0.4 g
Dietary fiber	0.2 g
Sodium	108.4 mg
Calcium	10.2 mg
Phosphorus	28.8 mg
Potassium	66.6 mg

Source: NEPA-UNICAMP, 2011; Lii; Chang; Young, 1982.

Regarding the study participants, 39 of the initial 53 reached the final stage, in which 21 individuals constituted the group that received the green banana cake and 18 comprised the group that consumed the cake made with ripe bananas (placebo). A total of four withdrawals were recorded by individuals who were no longer able to consume the food regularly and one due to intestinal discomfort. The other exclusions were due to lack of dialysis sessions, use of laxative medication, renal transplantation, modification of the dialysis regime, identification of irregularities in food consumption, and death. The descriptive characteristics of the study population are summarized in Table 2.

Table 2. Demographic, clinical, and nutritional characteristics of the population. Ribeirão Preto (SP), 2015

Variable	Green banana (n = 21)		Placebo (n = 18)		Total (n = 39)	
	N	%	N	%	N	%
Sex						
Female	11	28.2	5	12.8	16	41.0
Male	10	25.6	13	33.3	23	59.0
Age						
< 60 years	14	35.9	12	30.8	26	66.7
60 years or older	7	17.9	6	15.4	13	33.3
Hemodiálise duration						
< 1 year	0	0.0	1	2.6	1	2.6
1 to 5 years	11	28.2	11	28.2	22	56.4
> 5 years	10	25.6	6	15.4	16	41.0
Medication						
Sevelamer hydrochloride	14	35.9	15	38.5	29	74.4
Calcium carbonate	7	17.9	6	15.4	13	33.3

The mean and standard deviation of the participants' age was 52.1 (±17.3) years, and the average duration of hemodialysis, as well as the minimum and maximum values, were 4.5, 0.6, and 22.8 years, respectively.

The effects concerning the green banana and placebo cakes on the intestinal function of the study members can be observed in the results obtained from the application of the Bristol Stool Form Scale and Rome III Criteria, shown in Table 3. The Relative Risk assessment, adjusted to the co-variables "Fruit" and "Vegetable", was applied, and the consumption of fiber from these foods did not influence the results regarding intestinal function.

Table 3. Results after the application of the Bristol Stool Form Scale and Rome III Criteria. Ribeirão Preto (SP), 2015

Variable	Green banana (n = 21)				Placebo (n = 18)			
	T0		T1		T0		T1	
	N	%	N	%	N	%	N	%
Specific Rome III Criteria								
Straining at stool	7	18.0	5	12.8	6	15.4	3	7.7
Fragmented or hardened feces	6	15.4	4	10.2	2	5.1	3	7.7
Incomplete evacuation	6	15.4	3	7.7	2	5.1	5	12.8
Anorectal obstruction	2	5.1	3	7.7	1	2.6	0	0
Less than 3 bowl movements/week	6	15.4	3	7.7	3	7.7	1	2.6
Manual maneuvering	0	0	1	2.6	0	0	0	0
Bristol Scale								
1	7	18.0	0	0	6	15.4	2	5.1
2	6	15.4	4	10.2	0	0	3	7.7
3	6	15.4	11	28.2	11	28.2	6	15.4
4	2	5.1	4	10.2	1	2.6	6	15.4
5	0	0	2	5.1	0	0	1	2.6
6	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0

Intestinal constipation diagnoses are attributed to individuals that respond positively to two or more specific Rome III Criteria. Accordingly, 23.1% of the patients in the GB group and 15.4% of those in the Placebo group exhibited this disorder at the beginning of the study. These percentages decreased to 5.1% and 7.7%, respectively, after the intervention.

4. Discussion

Problems related to intestinal functioning were reported by many patients at the beginning of the present study (38.5%), a result also described in a survey conducted in 2008 with more than 400 Brazilian HD patients, in which the percentage of constipated individuals corresponded to 33.5% [4]. More current data continues to reflect the same scenario. A recent study conducted in the country showed that 32.8% of the evaluated individuals undergoing HD displayed intestinal constipation, which was also identified using Rome III Criteria, and resulted in the following percentages: 66% strained at stool, 42% stated having less than 3 bowel movements per week, 72% had fragmented or hardened stools and 92% reported incomplete sensation of evacuation [17]. These results are proportionally similar to those obtained in the present study, in which the primary complaints of the patients were associated with straining at stool and the reduced frequency of intestinal functioning. Complications such as the incomplete sensation of evacuation and hardened stools have also been observed, evidencing the high percentage of individuals who classified the aspect of their feces as of first degree on the Bristol Scale, which is characterized by fragmented, dry, and hardened stools.

In 2016, Lee *et al*. also utilized the Bristol Stool Form Scale, as well as the Rome III Criteria, to investigate the intestinal transit of 157 HD patients, and suggested that these techniques should be combined in the diagnosis of the problem, whereas single and isolated methods should not [18]. The authors further stated that the use of Rome III Criteria regarding the presence of fragmented or hardened feces is the optimal method of constipation prediction [18].

The intestinal malfunction affecting the dialysis population is directly related to reduced fiber intake due to low consumption of vegetables, which is often accompanied by water restriction, physical inactivity, and the use of chelating agents [4,19]. The data obtained from the dietary logs of the patients, which were investigated in order to estimate fiber consumption, showed that the intake of fruit and vegetable portions was inferior to the amount recommended by the National Kidney Foundation - Kidney Disease Outcomes Quality Initiative - NKF / KDOQI [20] throughout the study. Similar results were verified in the study conducted by Vaz and collaborators (2014), carried out with Brazilian patients on dialysis. The authors believe that the reduced consumption of these plants is due to misguided or implemented restrictions for the control of blood potassium concentrations [21].

After the intervention with green banana cake, a difference in fecal classification was noted according to the Bristol Scale, as well as in the number of individuals with complaints characterized as intestinal constipation. Despite the lack of statistical significance, these findings can be corroborated by the results described in a study on constipated children who received green bananas for 2 months. The authors verified more convenient evacuation and softer feces using the same methods applied in the present study and stated that these positive results are due to the resistant starch available in green bananas [22]. In animal models, the effects of the resistant starch present in green bananas were related to the facilitation of intestinal functioning but did not significantly influence fecal characteristics [23].

The green banana cooking process is believed to have led to losses in resistant starch, reducing the ability of the food to promote changes in the intestinal transit. Cardenette stated that green banana cooking in water, as conducted in the present study, is responsible for the reduction of approximately 70% in resistant starch content due to the starch's gelatinization process, which renders it digestible [24].

It is important to note that there were also changes, although less expressive, in the intestinal function of the members of the placebo group, indicating that a specific ingredient present in both preparations could be the causative agent of this modification. Among the possible ingredients and their respective nutrients, fibers and other non-digestible carbohydrates are present in bananas. However, they do not appear to have promoted the possible facilitation of intestinal functioning since their quantities are minimal both in green and ripe bananas, and are even smaller in the cake portions offered to the patients [25,26].

Among the remaining ingredients present in the composition of the green banana cake and the placebo cake, which could result in peristalsis stimuli, sunflower oil is noteworthy. Several studies highlight the laxative effect of mineral and vegetable oils. A study carried out with hemodialysis patients has recently confirmed that olive and linseed oils are as effective in improving intestinal constipation as mineral oil. Nonetheless, the applied doses were much more substantial than those employed herein. Therefore, the change in the patients' stool appearance may not be attributed to the oil alone [17,27]. Thus, it is believed that this set of ingredients, with possible positive effects on intestinal functioning, associated with low previous intake of fiber food sources, such as fruits and vegetables, can justify the discrete alterations observed in the intestinal habit of the study members.

Furthermore, it is worth mentioning that, despite being considered a pioneer in the development of a green banana-based diet, assessing its influence in the intestinal transit of hemodialysis patients, the present study has limitations. The probable loss of resistant starch during the food cooking process may have affected the study results. It is possible that an intervention using higher concentrations of green banana resistant starch would lead to more significant changes in intestinal functioning. Another factor that should also be taken into account is that the food consumption was not always performed within the dialysis service and, therefore, it was necessary to trust that the patients followed the study properly.

In any case, the incorporation of green banana in the diet of individuals on hemodialysis can be done as a way to add nutritional value to the food habit, given it retains no deleterious effects and has a promising influence on intestinal transit.

5. Conclusions

The members of the study constitute a representative sample of the overall HD patients, regarding descriptive characteristics, and exhibit a high prevalence of intestinal constipation.

In spite of the changes observed in the intestinal performance of the evaluated individuals, it was impossible to confirm that the green banana-based food was capable of improving bowel function. It can be suggested that greater amounts of resistant starch may lead to more consistent results with statistically significant differences.

List of Abbreviations

CKD: Chronic kidney disease
HD: Hemodialysis.

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