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CHARACTERIZATION OF NUTRIENT COMPOSITION IN FUNCTIONAL FOODS

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ABSTRACT

Functional foods contain in their composition some biologically active substances that when added to a usual diet produce metabolic or physiological processes, resulting in disease risk reduction and health maintenance. Acai, green tea, quinoa, chia, flaxseed and goji berry are examples functional foods due to their health benefits. The concentrations of Br, Ca, Co, Cl, K, Fe, Mn, Mg, Na, Rb and Zn were determined in quinoa, chia and flaxseed samples by Neutron Activation Analysis. The obtained results were discussed using the Dietary Reference Intake (DRI) for essential elements provided by the Institute of the Medicine of National Academy and a comparison between the different functional foods was carried out.

1. INTRODUCTION

The population has increasingly been concerned with the quality of food consumed, both in terms of its nutritional aspect and the possible harmful effects that may directly affect the quality of life. Human beings need a number of substances for the balanced maintenance of all their vital functions. The metabolism, vital functions and nutritional needs of an increasing number of inorganic elements have been studied by a wide variety of researchers [1].

Functional foods contain in their composition some biologically active substances that when added to a usual diet triggers metabolic or physiological processes, resulting in a reduction of disease risk and health maintenance [2]. These products can range from isolated nutrients, biotechnology products, dietary supplements, genetically engineered foods to processed foods and plant products. Functional foods should have beneficial properties in addition to the basic nutrients, being presented in the form of common foods.

They are consumed in conventional diets, and they demonstrate the ability to regulate body functions in order to help protect against diseases such as hypertension, diabetes, cancer, osteoporosis and coronary diseases [3]. Functional foods are characterized by a number of health benefits, in addition to the nutritional value inherent in their chemical composition, and may play a potentially beneficial role in reducing the risk of chronic degenerative diseases [4].

From time to time, new foods gain fame for their health benefits. Acai, green tea, quinoa, chia and goji berry are some of the more recent examples. They are called superfoods, because they are rich in antioxidant nutrients (vitamins and minerals), fibers and some substances that help reduce the absorption of fats and sugars. Several publications have shown that health is the main motivation for the consumption of functional foods [5-6].

Flaxseed, also known as linseed, is a plant that is cultivated primarily for the use of its seeds and fiber. Its level of omega-3 fatty acid, around 60%, makes the seed the greatest vegetarian source of this compound. The omega-6 fatty acid is also present in its seeds. Quinoa is distinguished as being a cereal with high-quality protein and absence of gluten. It has high levels of essential fatty acids, with good oxidative stability and, therefore, the potential to be used as an alternative culture in oil production. Chia seeds have been considered also a functional food due to their high levels of proteins, antioxidants, dietary fiber, vitamins, and minerals [6-8].

The analytical method to be used in the present work is the Neutron Activation Analysis (NAA). The NAA method has been used for many years at LAN for the analysis of biological matrices since it presents great sensitivity and accuracy for most elements of nutritional and toxicological interest. In addition, it has played an important role in monitoring trace elements in various foods, and has contributed significantly in terms of establishing daily intake values of many essential elements [9].

2. MATERIALS AND METHODS

2.1. Sampling and Preparation of Functional Foods

Six samples from three species of functional foods commercially available to consumers were purchased from markets all around São Paulo city. The samples analyzed were chia seeds, quinoa and flaxseed were ground and homogenized using a household mixer, fitted with titanium blade, until they acquire a powder consistency.

2.2. Instrumental Neutron Activation Analysis (INAA)

For the Cl, K, Mg, Mn and Na determination by INAA about 0.100 g of the functional food samples were irradiated for 20 seconds in a thermal neutron flux of 1.0×10^{12} cm^{-2} s^{-1} in a pneumatic station of the nuclear research reactor IEA-R1 at IPEN-CNEN/SP.

For the Ca, Co, Cr, Fe, Se e Zn determination about 0.200g of the food samples were irradiates for 8 hours in a thermal neutron flux of 4.5×10^{12} cm^{-2} s^{-1} in the core of nuclear research reactor IEA-R1.

Primary standards of the elements and biological certified reference material were simultaneously irradiated with the samples for standardization and quality control purposes.

Gamma ray measurements were performed using a GC2018 Canberra HPG e detector coupled to a Canberra DSA-1000 multichannel analyzer. Gamma ray spectra were collected and processed using a Canberra Genie 2000 version 3.1 spectroscopy software. Element content calculations were carried out using a Microsoft Excel spreadsheet.

2.3. Statistical Analysis

Data obtained were subjected to analysis of variance (ANOVA). Differences among means were determined using the Tukey test.

2.4. Quality Control

The analytical quality of the results for the technique used (INAA) was checked for the accuracy and precision of the experimental values obtained for the reference materials, Oyster Tissue SRM 1566b, Bovine Liver SRM 1577b from the National Institute of Standard & Technology, and Mixed Polish Herb (MPH2) from the Institute of Nuclear Chemistry and Technology- (INCT- Poland). The results showed relative errors less than 15% and relative standard deviations below 10%, as may be verified in Table 1. Figure 1 shows the En score values calculated for the Reference materials analyzed and the values were between -2 to 2. This means that the determined concentrations were considerate satisfactory within a 95% confidence interval.

Table 1: Result of element concentrations in the Reference Materials

Element	Oyster Tissue SRM 1566b (OT)		Mixed Polish Herb INCT-MPH2		Bovine Liver SRM 1577b (BL)	
	This study	Certified Value	This study	Certified Value	This study	Certified Value
Br mg/kg	-	-	7.37 ± 0.92	7.71 ± 0.61	10.5 ± 0.7	(9.7)[a]
Ca %	0.086 ± 0.015	0.0838 ± 0.0020	1.126 ± 0.067	1.08 ± 0.07	-	0.0116 ± 0.0004
Cl %	0.518 ± 0.020	0.514 ± 0.010	0.259 ± 0.033	0.287 ± 0.020	0.249 ± 0.016	0.278 ± 0.006
Co µg/kg	422 ± 85	371 ± 9	208 ± 4	210 ± 25	265 ± 4	(250)[a]
Fe mg/kg	207 ± 20	205.8 ± 6.8	495 ± 10	(460)[a]	200 ± 10	184 ± 15
K %	0.679 ± 0.094	0.652 ± 0.009	2.03 ± 0.10	1.91 ± 0.12	1.028 ± 0.016	0.994 ± 0.002
Na %	0.338 ± 0.034	0.3297 ± 0.0053	0.0414 ± 0.0016	(0.0350)[a]	0.239 ± 0.012	0.242 ± 0.006
Mg %	0.114 ± 0.010	0.1085 ± 0.0023	0.349 ± 0.038	0.292 ± 0.018	0.063 ± 0.025	0.0601 ± 0.0028
Mn mg/kg	17.9 ± 2.3	18.5 ± 0.2	215 ± 6	191 ± 12	10.7 ± 0.7	10.5 ± 1.7
Rb mg/kg	3.136 ± 0.022	3.262 ± 0.145	9.9 ± 0.4	10.7 ± 0.7	14.3 ± 0.9	13.7 ± 1.1
Zn mg/kg	1333 ± 238	1424 ± 46	28.4 ±2.1	33.5 ± 2.1	122 ± 11	127 ± 16

[a] : Informative value

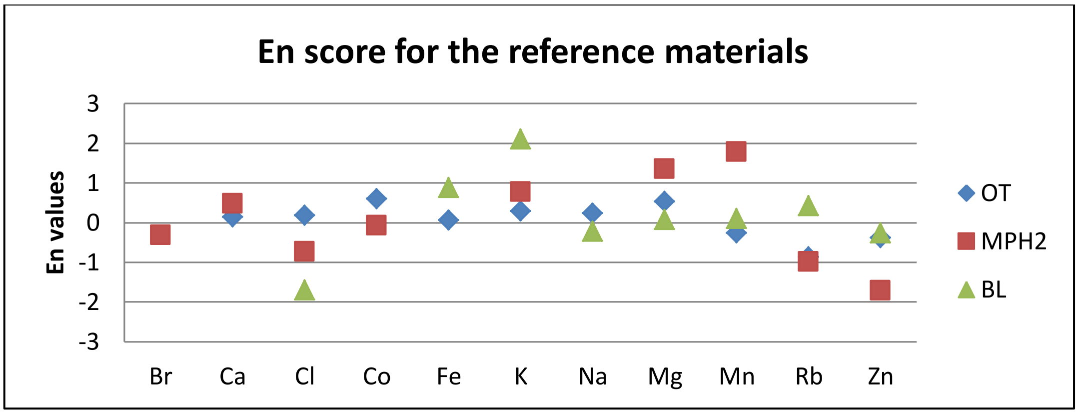

Figure 1: En score values for the reference materials analyzed by INAA

3. RESULTS AND DISCUSSION

3.1 Essential element concentrations in the functional foods.

Table 2 shows the eleven essential element concentrations in the functional foods, quinoa, chia seeds and three types of flaxseed: golden, whole-grain and seed analyzed by INAA.
Anova and Tukey tests were applied to verify if there are significant differences among the three types of flaxseed analyzed. The three types of flaxseed showed significant differences for the majority of the element concentrations. Only Cl, Fe and Zn concentrations did not present significant difference between the whole-grain and seed flaxseed samples, Ca for golden and seed, and K for whole grain and golden.

Table 2: Essential element in the functional foods by INAA

Element	Flaxseed			Quinoa	Chia seed
	Whole-grain	Golden	Seed		
Br mg/kg	1.87 ± 0.14[a]	1.09 ±0.15[b]	0.67 ± 0.09[c]	0.28 ± 0.04	1.42 ± 0.14
Ca %	0.228 ± 0.017[a]	0.273 ±0.015[b]	0.267± 0.014[b]	0.074 ± 0.007	0.523 ± 0.025
Cl %	0.095 ± 0.004[a]	0.069 ± 0.003[b]	0.0091 ± 0.006[a]	0.061 ±0.005	0.0069 ± 0.010
Co µg/kg	207.6 ± 9.7[a]	290 ± 17[b]	857 ± 39[c]	36.9 ± 4.5	1038 ± 308
Fe mg/kg	48.4 ± 5.4[a]	54.9 ± 2.1[b]	50.0 ± 2.8[a]	36.5 ± 1.8	82.7 ± 5.9
K %	0.668 ± 0.019[a]	0.692 ± 0.018[a]	0.889 ± 0.061[b]	0.675 ± 0.039	0.577 ± 0.031
Na %	0.0625 ± 0.032[a]	0.027± 0.001[b]	0.0080 ± 0.0008[c]	0.0012 ± 0.0001	0.00064 ± 0.00001
Mg %	0.302 ± 0.011[a]	0.394 ± 0.03[b]	0.241 ± 0.037[c]	0.164 ± 0.016	0.305 ±0.012
Mn mg/kg	25.8 ± 2.7[a]	32.3 ± 2.2[b]	32.3 ± 2.8[b]	24.7 ± 1.8	85.5 ± 5.6
Rb mg/kg	1.83 ± 0.14[a]	4.01 ± 0.39[b]	4.98 ± 0.40[c]	12.1 ± 0.7	16.8 ± 0.7
Zn mg/kg	48.8 ± 1.4[a]	66.9 ± 4.7[b]	50.1 ± 6.2[a]	23.2 ± 1.6	54.4 ± 3.0

*same letter indicate that the difference of the means is not significant at the 0.05 level

Some literature data are shown in Table 3 for only quinoa samples compared with the obtained concentration in this study. There is no more data for other elements and for the flaxseed and chia samples.

Table 3: Element concentration in quinoa sample from different studies (mg/100g)

Reference	Ca	K	Mg	Fe	Mn	Zn
Alvarez *et al*[10]	32.9 ± 3.3	-	206.8± 6.4	5.5 ± 0.5	-	1.8 ± 0.0
Nascimento *et al*[7]	44 ± 1.7	664 ± 15	197 ± 8.1	5.46 ± 0.02	1.95 ± 0.10	2.93 ± 0.07
Bolanos *et a*l [11]	44.7 ± 0.6	603.5 ± 5.2	177.0 ± 1.9	-	2.41 ± 0.02	2.81 ± 0.04
This study	73.7 ± 6.7	675 ± 39	164 ± 16	3.65 ± 0.18	2.47 ± 0.18	2.32 ± 0.16

3.2. Contribution of the functional food to recommended intake for the essential elements

According to the National Household Food Budget Institute Survey, POF 2008-2009 from Brazilian Institute for Geography and Statistic (IBGE) the consumption of nut and seed by the population is about 2 g/day.[9]. In the Table 4 are shown the Dietary Recommended Intake values (DRI) for the essential elements for adults 19-50 years and >50 years [12] and the contribution of mineral intake of DRI expressed in %, based on consumption of 2g of flaxseed, quinoa and chia.

Table 4: Contribution (%) of essential element for DRI based on consumption of 2g seed/day

Element	Life stage groups	DRI mg/day	Contribution of essential elements for DRI (%)		
			Golden Flaxseed	Quinoa	Chia seed
Ca	19-50years	1000	0.55	0.15	1.5
	>50year	1200	0.46	0.12	0.87
K	19-50years	4700	0.29	0.29	0.25
	>50year	4700	0.29	0.29	0.25
Fe	19-50years	8/18[a]	0.61	0.91	2.1/0.92
	>50year	8	1.3	0.41	2.1
Mg	19-50years	420/320[a]	1.8/2.4	0.78/1.02	1.45/1.90
	>50year	320	2.4	1.02	1.90
Mn	19-50years	2.3/1.8 [a]	2.8/ 3.6	2.2/2.8	7.4/9.5
	>50year	2.3/1.8 [a]	2.8/ 3.6	2.2/2.8	7.4/9.5
Na	19-50years	1200-1500	0.045-0.036	0.0020 -0.0016	0.0011-0.0009
	>50year	1200-1500-	0.045-0.036	0.0020 -0.0016	0.0011-0.0009
Zn	19-50years	11/8[a]	1.2/1.7	0.42/0.58	1.0/1.4
	>50year	11/8[a]	1.2/1.7	0.42/0.58	1.0/1.4

[a]: for Male/Female

The contributions to dietary daily intake are not relevant due to the low consumption (2g/day) of this kind of food by the population. The contribution for DRI varies between 0.0091% (Na in chia) and 9.5% (Mn in chia). However, if the daily consumption increases these foods can be considered good sources of essential elements. It should be noted that the Na concentrations are very small, mainly in chia seed, suggesting the use these functional foods in a hypertensive diet.

3. CONCLUSIONS

Important nutritional elements, like Br, Co, Cl, Ca, Na, K, Mg, Mn, Fe, Rb and Zn were determined by Instrumental Activation Analysis in three kinds of functional foods. The results showed that if daily consumption increases these foods can be considered good sources of essential elements.

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