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FOOD GROUP CONTRIBUTION OF ESSENTIAL ELEMENTS OF THE SÃO PAULO STATE MARKET BASKET

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ABSTRACT

To establish a Market Basket of São Paulo state seventy-one foods, with a mean consumption of more than 2 g day^{-1} per person, were grouped into 30 food categories. The food groups were: cereals, leguminous, leafy vegetables, fruity vegetables, tuberous vegetables, tropical fruits, other fruits, flours, pastas, breads, biscuits, prime grade beef, standard grade beef, pork meats, other meats, poultry, milk/cream, other dairy products, sugars, sweets, salts, sauces, oils, fats, alcoholic beverages, non-alcoholic beverages, coffee, ready-made dishes, saltwater and freshwater fishes. Information about individual food consumption was obtained from a recent national household food budget survey "POF 2002-2003" conducted by the Brazilian Institute for Geography and Statistics from July 2002 to June 2003. Sampling and kitchen preparation of foods were carried out in restaurants of the University of São Paulo. Each food item was individually prepared table-ready. Foods of the same group were mixed, homogenized, pulverized and analyzed for the determination of Ca, Cr, Fe, K, Na and Zn concentrations by Instrumental Neutron Activation Analysis. Average daily intake of each element was calculated by multiplying the element concentration in the food by the corresponding weight of the ready-to-consume food group. The contribution of each food group to the total daily intake of elements by the ready-to-consume food groups of the Market Basket was evaluated. The food groups representing the highest contributions were salts: 79% Na; breads: 37% Fe and 46% Cr; cereals: 19% Zn and milk/cream: 58% Ca and 24% K.

1. INTRODUCTION

The Market Basket (MB) means the approach adopted worldwide in estimating the daily intakes of analytes of interest by chemical analysis, for a large-scale population over a specific period of time. The MB consists of foods reflecting a defined total diet, based on

amounts of food consumed, provided by representative national surveys. The MB involves preparing food as they would be consumed (table-ready) [1-3]. The MB approach has been encouraged by World Health Organization (WHO) and has been the most adequate method to assess the dietary intakes of nutrients [1, 4-5].

Although there have been studies since 1961 in several countries concerning MB [2-4, 6-16], in Brazil they are still scarce. In the last few years, the IPEN-Neutron Activation Analysis Laboratory has verified the essential element concentrations in foods and diets, but for small groups [17-18]. The Instrumental Neutron Activation Analysis (INAA) has been successfully applied.

The MB approach is considered an important tool and scientific bases for monitoring dietary intakes, to evaluate the dietary safety, the nutritional quality and for estimating the compliance with nutritional requirements [3-4].

The research over the last years shows that toxic and nutritionally important chemicals exert greater influence over human healthy than previously thought and the relationship between nutrients, mainly micronutrients and healthy is well established [6,18]. Disturbances such cancer and cardiovascular disease may occur when there is micronutrient deficiency. This present work aimed at evaluating the intake of some micronutrients in the diet of São Paulo State population, in a period of time.

2.1. **Market Basket Methodology**

This methodology was based on MB carried out in different countries. This MB corresponds to 72% of the daily food intake for São Paulo State population [19]. The percentage was defined by the available resources for analytical procedures in the laboratory. The establishment of MB consisted of:

1) Selection of foods: the information about individual food consumption in São Paulo State was obtained from a national household food budget survey, the "POF 2002-2003" conducted by the Brazilian Institute for Geography and Statistics from July 2002 to June 2003, including 5,440 foods [20-21]. The criteria was sampling of 71 foods consumed more than 2g/day/person, except for fishes. Although consumption of fishes was lower than 2g/day, they were included in the MB due to their important toxic element sources, which would be useful to other studies based on MB;

2) Selection of approach of MB into groups, instead of individual approach: the 71 foods were aggregated into 30 food groups, based on their similar food classification;

3) Food sampling, food and food group samples preparation: collection and preparation in restaurants of the University of São Paulo, preparing table-ready food individually, mixing foods of the same food group in proportions based on the consumption date. The weights of foods from the "POF 2002-2003" were corrected for edible portions and for the ready-to-consume foods.

The Table 1 shows the MB with table-ready food and food group participation on the total weight.

Table 1. Market Basket with 71 food items into 30 groups and their participation on total weight

Food groups	Foods	Weight table-ready foods (g/day)	% weight
1-Cereals	polished rice, rice, corn	139.30	18.20
2-Leguminous	black bean, bean	49.07	6.41
3-Leafy vegetables	lettuce, cabbage	3.15	0.41
4-Fruity vegetables	onion, tomato	25.36	3.31
5-Tuberous vegetables	potato, carrot	15.57	2.03
6-Tropical fruits	pineapple, dwarf banana, banana, orange, papaya, mango, watermelon	24.76	3.23
7-Other fruits	apple	3.11	0.41
8-Flours	cassava flour, wheat flour	11.94	1.56
9-Pasta	spaguetti	12.81	1.67
10-Breads	french loaf, sandwich loaf	42.52	5.55
11-Biscuits	cookie	2.64	0.34
12-Prime grade beef	boneless sirloin steak, round beef, top loin steak, round steak, tip steak	6.96	0.91
13-Standard grade beef	Brisket, rib roast, shank, cross cut, shoulder	6.43	0.84
14-Pork meat	cooked sausage	2.17	0.28
15-Other meats	sausage	3.06	0.40
16-Poultry	frozen chicken, chilled chicken chicken breast, chicken thigh	9.20	1.20
17-Milk/cream	pasteurized milk, milk, skim milk, sterilized milk, low fat milk, whole milk, condensed milk	138.52	18.10
18-Other dairy products	yogurt	6.57	0.86
19-Sugars	refined sugar, crystallized sugar, powdered sugar	47.10	6.15
20-Sweets	ice-cream	2.88	0.38
21-Salts	salt	5.93	0.77
22-Sauces	processed tomato, tomato sauce	4.07	0.53
23-Oils	soy oil	20.84	2.72
24-Fats	margarine	3.45	0.45
25-Alcoholic beverages	beer	17.58	2.30
26-Non-alcoholic beverages	soft drink, coke, other coke, orange soft drink, guarana, mineral water, fruit juice	105.26	13.75
27-Coffee	coffee powder	53.11	6.94
28-Ready-made dishes	smoked chicken	1.26	0.16
29-Saltwater fishes	sardine, haddock white drum	0.60	0.08
30-Freshwater fishes	red fish	0.24	0.03
Total		**765.5**	**100**

2.2. Instrumental Neutron Activation Analysis

Each table-ready food group was freeze-dried, when necessary, ground, homogenized in a domestic blender with titanium blades, analyzed by INAA to determine the concentrations of Ca, Cr, Fe, K, Na and Zn.

2.2.1. Preparation of samples and reference materials

About 150 to 200 mg of food group samples and of reference materials Oyster Tissue (SRM 1566b), Mussel Tissue (SRM 2976), Bovine Liver (SRM 1577 b), Whole Milk Powder (RM 8435), Wheat Flour (SRM 1567), Mixed Polish Herbs (MPH2) were weighted in clean polyethylene bags. Samples food groups of oils and fats were weighted in polyethylene capsules.

2.2.2. Preparation of Na, K, Ca, Se, Cr, Fe and Zn Standards

Standards of Na, K, Ca, Se, Cr, Fe and Zn were prepared from appropriate dilutions of their Spex solutions. Aliquots (25 – 100 μL) taken from such solutions were sucked up by pipette, transferred on the Whatman 40 filter paper and dried under infrared lamp. After drying, filter papers were transferred to clean polyethylene bags. Standards were prepared with: 992 μg de Ca, 2.48 μg de Cr, 495 μg de Fe, 990 μg de K, 12.4 μg de Na and 24.6 μg de Zn.

2.2.3. Samples and standard irradiations

About 150 to 200 mg of food group samples and of reference materials were irradiated with element standards for Ca, Fe, Na, K, Cr and Zn for 8 hours under thermal neutron flux of 4.5×10^{12} n cm^{-2} s^{-1} at the nuclear research reactor IEA-R1 of IPEN/CNEN-SP.

2.2.4. Gamma spectrometry

After appropriate decay periods, γ-ray spectra of food group samples, reference material samples and element standards were measured with Ge detector models of EG&G ORTEC and Canberra. The gamma-ray spectra were analyzed using the VISPECT 2 software.

3. RESULTS AND DISCUSSION

3.1. Analytical Method Validation

For the validation of the methodology seven reference materials were analyzed: Mixed Polish Herbs (INCT-MPH2) from Polish Institute of Nuclear Chemistry and Technology and Mussel Tissue (SRM 2976), Whole Milk Powder (RM 8435), Wheat Flour (SRM 1567), Oyster Tissue (SRM 1566b), Bovine Liver (SRM 1577 b) and Peanut Butter (SRM 2387) from NIST (National Institute of Standards and Technology-USA). The mean value concentration and standard deviation obtained for Ca, Cr, Fe, K, Na and Zn in these reference materials was compared to certified values of the same reference materials, as showed in Table 2.

Table 2. Essential element results in Certified Reference Materials

Elements		**Reference Materials** (Means ±DP)[a]						
		INCT-MPH2	Mussel Tissue	Whole Milk Powder	Wheat Flour	Oyster Tissue	Bovine Liver	Peanut Butter
Ca (mg kg^{-1})	This study	10918±441	8120±371	9454±291	229±19	863±61	133±11	412±28
	Certified value	10800±700	7600±300	9220±490	191±4	838±20	116±4	411±18
Cr (µg kg^{-1})	This study	1762±66	524±41	nd	nd	601±60	nd	nd
	Certified value	1690±130	500±160	-	-	-	-	-
Fe (mg kg^{-1})	This study	490±21	172±7	0.9±0.1	13.4±1.1	194±11	190±18	17.6±2.4
	Certified value	460[b]	171±4.9	1.8±1.1	14.1±0.5	205.8±6.8	184±15	16.4±0.8
K (mg kg^{-1})	This study	18693±1502	nd	12147±679	1208±91	6334±151	nd	6338±606
	Certified value	19100±1200	-	13630±470	1330±30	6520±90	-	6070±200
Na (mg kg^{-1})	This study	357±31	30122±50	3085±49	6.1±0.5	2871±105	nd	4796±410
	Certified value	350[b]	35000±100	3560±400	6.1±0.8	3297±53	-	4890±140
Zn (mg kg^{-1})	This study	32±1	143±7	25±2	10.7±0.4	1457±10	121±4	27.9±2.7
	Certified value	33.5±2.1	137±13	28±3.1	11.6±0.4	1424±46	127±16	26.3±1.1

[a]: Means and standard deviation of four determination [b]:informative value;
nd: not determined

Based on the En-score (|En|) tests [22], values were calculated. The value 0 < |En| < 2 was satisfactory at the 95% of confidence level. The values obtained varied from -1.8 to +1.90, (except for -3.7 Na in the Oyster Tissue), indicating that the results are in agreement with certified values.

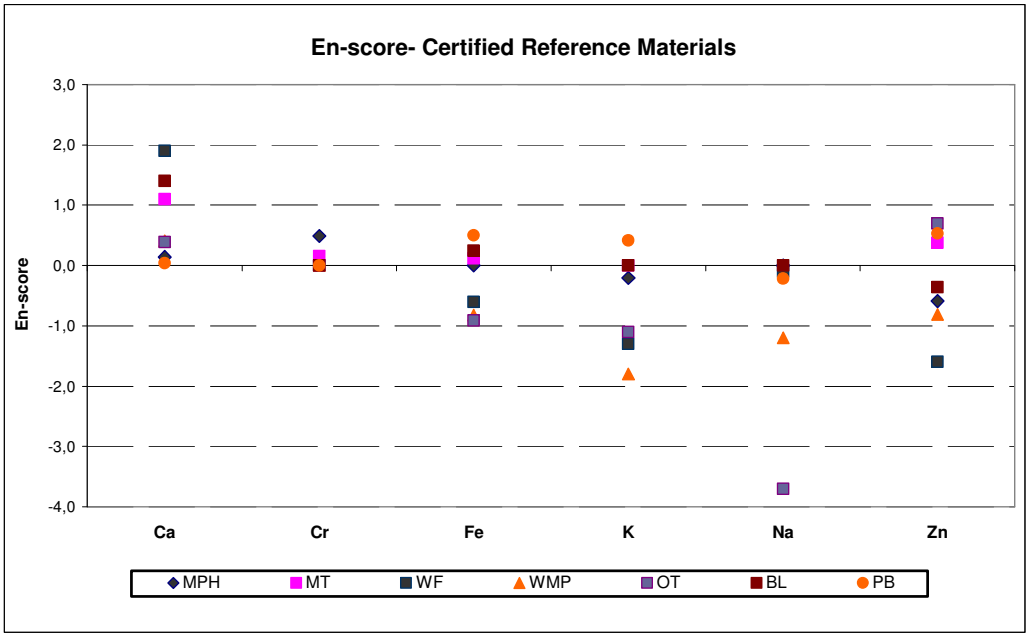

Figure 1. En Score Certified Reference Materials

3.2. Elements results in food groups

3.2.1. Elements concentrations

The mean values and standard deviation for the elements Ca, Cr, Fe, K, Na and Zn obtained of, at least, in three determinations in samples of each food was determined. The results were related to the dry mass of the samples.

Table 3– Element concentration in the food groups (dry–weight)

Food groups	mg/kg					µg/kg
	Na	K	Ca	Fe	Zn	Cr
cereals	1.8 ± 0.3	236 ± 2	58 ± 7	0.9 ± 0.2	5.7 ± 0.4	9 ± 1
leguminous	1.5 ± 0.4	2635 ± 157	809 ± 97	26 ± 2	12.6 ± 0.8	9 ± 2
leafy vegetables	36.0 ± 0.2	2385 ± 149	473 ± 51	2.7 ± 0.1	2.0 ± 0.1	48 ± 1
fruity vegetables	36 ± 1	2319 ± 30	227 ± 9	2.8 ± 0.2	1.52 ± 0.08	6 ± 2
tuberous vegetables	16.0 ± 0.9	3532 ± 75	140± 4	4.4 ± 0.2	3.5 ± 0.2	6 ± 1
tropical fruits	4.0 ± 0.5	2334 ± 244	186± 9	2.7 ± 0.5	1.64 ± 0.09	25 ± 6
other fruits	4.5 ± 0.2	1059 ± 22	74 ± 2	1.5 ± 0.2	0.65 ± 0.09	16 ± 2
flours	13.9 ± 0.2	2315 ± 120	609 ± 68	45 ± 5	12 ± 1	52 ± 7
pasta	101 ± 5	146 ± 2	111 ± 1	21.2 ± 0.6	2.3 ± 0.1	19.3 ± 0.3
breads	5561 ± 654	1136 ± 214	307 ± 20	49 ± 2	11.9 ± 0.9	225 ± 32
biscuits	3574 ± 49	907 ± 53	393 ± 37	47 ± 2	9.9 ± 0.6	74 ± 10
prime grade beef	1085 ± 7	5322 ± 549	142 ± 38	30 ± 1	61 ± 1	56 ± 10
standard grade beef	1478 ± 157	4049 ± 263	134 ± 41	34 ± 3	98 ± 3	110 ± 10
pork meats	10101 ± 1736	730 ± 94	849 ± 75	20 ± 1	12.1 ± 0.4	117 ± 16
other meats	6734 ± 171	2657 ± 42	260 ± 43	13 ± 2	28 ± 2	71 ± 21
poultry	695± 68	2926 ± 287	108 ± 8	8.2 ± 0.4	21 ± 2	60 ± 4
milk/cream	445 ± 20	1465 ± 76	1166 ± 32	0.4 ± 0.1	3.9 ± 0.1	-
other dairy products	329 ± 11	1281 ± 66	1143 ± 85	0.45 ± 0.02	3.4 ± 0.2	24 ± 4
sugars	25 ± 1	63 ± 1	106 ± 4	1.4 ± 0.3	0.25 ± 0.02	44 ± 6
sweets	632 ± 52	2167 ± 105	1681 ± 220	39 ± 4	5.0 ± 0.1	799 ± 8
salts	256185 ± 6847	-	-	6 ± 2	-	-
sauces	5542 ± 219	3714 ± 379	195 ± 13	8.7 ± 0.6	1.69 ± 0.06	68 ± 15
oils	0.9 ± 0.4	-	-	3.1 ± 0.3	-	-
fats	21 ± 1	138 ± 21	22 ± 9	5.4 ± 0.4	0.28 ± 0.02	-
alcoholic beverages	26 ± 2	172 ± 10	30 ± 5	0.08 ± 0.02	0.030 ± 0.001	12 ± 1
non-alcoholic beverages	1.5 ± 0.2	0.51 ± 0.03	-	-	-	-
coffee	3.29 ± 0.03	1710 ± 15	61 ± 7	1.07 ± 0.06	0.22 ± 0.02	2.6 ± 0.4
ready-made dishes	892 ± 77	3501 ± 119	110 ± 12	8.1 ± 0.4	17 ± 2	25 ± 5
saltwater fishes	1912 ± 69	2827 ± 163	1827 ± 134	9.9 ± 0.3	8.3 ± 0.3	25 ± 1
freshwater fishes	424 ± 16	3069 ± 172	228 ± 16	4.2 ± 0.4	3.7 ± 0.2	11.0 ± 0.4

To obtain the elements concentration on table-ready food groups, the concentrations were corrected for humidity and hydration values.

3.2.2. Element daily dietary intakes and food groups contribution

The average daily intake of each element was calculated by multiplying the concentration of each element in each table-ready food group by the respective weight (g/day) of food group in the MB (Table 1) and summing the products from all food groups. To analyze the daily intakes and the contribution of the elements it is important to know the concentration of each element in the food groups, besides to observe the percentage of each food group in the weight of the MB (Table 1). The significant dietary sources of the elements can be diluted by their small amount in the MB.

Based on the daily intakes, the contribution of food groups to total intake of each element is shown at Fig. 1.

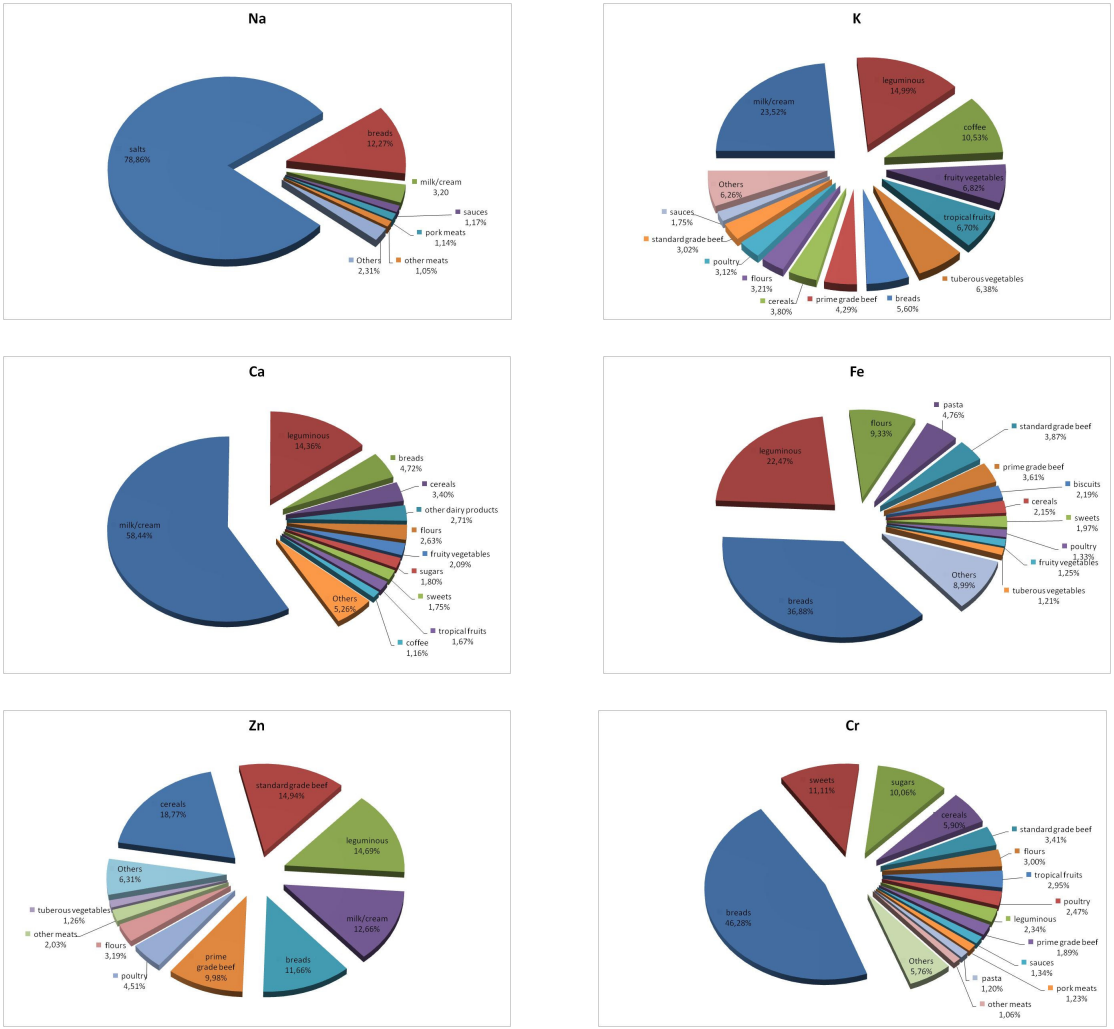

Figure 1. Contribution of food groups to the daily intake of essential elements

Large variability can be observed among the food groups in relation their contribution on Ca, Cr, Fe, K, Na and Zn intakes.
Milk/cream group represented 58% of the daily intake of Ca and 18% of the total weight of ready-to-consume food groups of the MB (Table 1). Other dairy products presented the small consumption of 6.57g/day (0.86% of total weight), as shown in Table 1, contributing only to 2.7% of the Ca intake. Among other sources of Ca, the Leguminous group highlighted with 14.4% of the daily intake of Ca.
Breads represented 46% of the daily intake of Cr, even representing about 5.5% of the total weight of ready-to-consume food groups of the MB (Table 1).
The food groups composed of Fe fortified wheat flour products (Breads, Flours and Pasta) and Leguminous were the major contributors to the total intake of Fe in the MB.
The biggest intakes of K in the MB were from Milk/cream (23.6%) and Leguminous (15%) groups. Fruits and vegetables groups, good sources of K, only contributed to 9.39% in the MB (Table 1).
In the total intake of Na, 21% were from different food groups and 79% were from Salts in the MB.
The greatest contribution to the daily intake of Zn was Cereals (18.7%). It is due to the fact of even if Cereals had low concentrations of Zn, they have a high consumption as shown in Table 1. The main sources of Zn such as red meats (prime and standard grade beef and sausages) represented only 3.91% of the total weight of table-ready food groups of this MB (Table 1).

4. CONCLUSIONS

The contributions of the food of the Market Basket to the intake of essential elements for the population on São Paulo State is dependent on the concentration of the element in the samples, which was determined by INAA, and on the amount of each food present in the MB.

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