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Assessment of iodine content in Brazilian duplicate portion diets and in table salt

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Excess dietary intake may increase the risk for the hyperthyroidism in the elderly. This study investigated iodine dietary intake by epithermal neutron activation analysis (ENAA) analyzing duplicate portion diet and fortified table salt samples. Duplicate diet samples were obtained from a group of twenty-five steel mill workers from the city of São Paulo, over a 3-day period. The samples were freeze dried, mixed and homogenized. Fortified table salt brands were collected from the market and were analyzed with no pre-treatment. Assays for the iodine concentration in the table salt samples revealed values between 24 to 65 mg/kg. The average iodine daily intake for the worker´s diets was 813 μg/day, ranging from 402 to 1363 μg/day. In some cases daily intakes were around 10 times higher than the recommended dietary allowance (RDA) value (150 μg/day).

Introduction

Low iodine levels in the diet lead to iodine deficiency disorders (IDD). Health problems connected with a deficit of iodine are still relevant in a number of countries.[1] Since the 90's there has been dramatic progress in the campaign to eliminate iodine deficiency, but this deficiency still remains the world's leading cause of mental retardation and impaired psychomotor development in young children. In its most extreme form, iodine deficiency causes cretinism. It also significantly raises the risks of stillbirth and miscarriage for pregnant women. Most commonly and visibly associated with goiter, iodine deficiency takes its greatest toll in impaired mental growth and development.[2]

Salt iodization has been adopted as the main strategy to eliminate IDD as a public health problem. There is also an intensive international effort to fortify the cooking salt with iodine in several countries. Brazil has added small quantities of iodine in its table salt as a requirement of a fortification program to prevent diseases in the population, since the 50's.[3]

However, an acute increase in iodine intake when there is chronic iodine deficiency carries risks. The most serious and common complication of salt iodization is the development of iodine-induced hyperthyroidism (IIH), which affects mainly older people with nodular goiters.[4] High iodine intake has been detected in some countries.[5,6] According to CAMARGO et al.[6] for almost 6 years the Brazilian population has been exposed to excessive iodine intake. DUARTE et al.[7] examined 844 schoolchildren from São Paulo and observed that 57% of the children had elevated urinary iodine excretion, over 300 μg iodine·L^{-1} and 21% presented higher values than 600 μg iodine·L^{-1}. These high values indicated excessive iodine ingestion.

For these reasons it is important to evaluate the iodine dietary intake through foodstuffs. In this study the iodine dietary concentration in Brazilian duplicate portion diet and fortified table salt samples was determined by epithermal neutron activation analysis (ENAA). This method has been used for non-destructive determination of iodine in food and food products.[8,9]

Experimental

Sampling of duplicate portion diet

Twenty five different duplicate diet samples were obtained from a group of steel mill workers of the city of São Paulo, over a 3-day period. The diets were collected by the duplicate portion method, which is considered the most appropriate when a small group is evaluated.[10]

Duplicates of all the meals were collected in pre-cleaned polyethylene containers to collect the meals and beverages consumed. The individual samples of each participant were prepared and analyzed separately. The inedible portions (like bone, peel of fruits) were discarded and the equivalent of the food consumed was weighed and stored in a refrigerator. After the period of collection, the duplicate portions collected were mixed and homogenized in a domestic blender which was coated with Teflon and equipped with titanium blades. The homogenized samples were freeze-dried for about 48 hours and, thereafter, were again homogenized in the blender.

Salt samples

Ten brands of table salt were purchased from retail outlets in São Paulo during the years 2001–2002. These brands were from different parts of the country.

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Epithermal instrumental neutron activation (ENAA)

For ENAA, aliquots of the diet samples (100 mg), table salt (80 mg) were weighed in acid cleaned polyethylene bags. Iodine standards were prepared by dropping the suitable solution (KIO_3) on Whatman 42 paper and dried at room temperature. The samples and standard were wrapped with a cadmium sheet with a thickness of 2 mm and then were irradiated for 2 minutes in the thermal neutron flux of 10^{11} $cm^{-2} \cdot s^{-1}$ at the research reactor IEA-R1 of IPEN-CNEN/SP.

The amounts of iodine in the diet and table salt samples were obtained from the measured γ-activities in the samples and comparing it with the standard after 5 minutes of cooling time. The samples and standard were counted for 10 minutes by a Ge detector (Model POP TOP – EG&G ORTEC) with a resolution of 1.90 keV for the 1332.49 keV γ-ray peak of ^{60}Co. The γ-ray spectrum was analyzed using the VISPECT 2 software.

Results and discussion

Three standard reference materials (SRM), NIST 1549 Non Fat Milk Powder, NIST 8435 Whole Milk Powder and NIST 1548a Typical Diet were simultaneously determined with samples as analytical quality control. Table 1 presents SRM results that are in good agreement with the certified values.

Based on the ISO/IUPAC[11] the concentrations of iodine determined in SRM's were converted into *z*-score. In all of the reference materials analyzed the *z*-score values were $|z| \leq 1$, showing that the results were considered satisfactory, in the 99% confidence interval of the certified values.

Iodine concentrations were determined by ENAA in ten different table salt brands and twenty-five duplicate diet samples. These are presented in Tables 2 and 3, respectively.

The iodine concentration varied from 24.1 to 64.9 mg/kg in the table salt samples. According to the Brazilian legislation[12] table salt will be considered for human consumption if the iodine level is between 20 to 60 mg/kg. Then, 90% of the table salt analyzed was considered adequate for consumption. Only one of the samples analyzed exceeded the maximum value.

The average iodine concentration was 1.70 mg/kg, and ranged from 1.29 to 2.16 mg/kg in the duplicate diet samples (Table 3). The daily intakes of iodine were obtained by multiplying the concentrations in individual diet samples by the total weight of food consumed by each participant. The average amount of food consumed daily was about 490 g dry weight. The mean daily intake of iodine was 813 μg per person.

The dietary iodine intakes determined in this study were higher than the Dietary Reference Intake set by the US National Research Council[13] which is 150 μg/day for the adults in the range of 30 to 70 years old.

Roughly 8% of the diet samples analyzed presented iodine daily dietary intake values higher than the Tolerable Upper Intake Levels (UL 1100 μg/day). These results are worrisome because excessive iodine intake has been also associated with increased thyroid volume, increase the risk for chronic autoimmune thyroiditis specially in women and for hypertyroidism in the elderly.[4,6]

Table salt is the main source of iodine daily intake. In the last years, many Brazilian diets have presented high sodium and chloride intakes. In some cases the Na dietary intake exceeded 85% of the recommended daily intake.[10]

DUARTE et al.[7] and CAMARGO et al.[6] recommended that the addition of iodine to salt for human use should be revised by the Health Authorities. Our data support this revision as we obtained iodine values well over the recommended values. These results underline the importance of monitoring the salt-iodization process and evaluation of iodine ingestion through diets.

Table 1. Results of Iodine in the NIST reference materials by ENAA (in mg/kg)

Reference material	Average ± SD (*n*)	Certified values	*z*-Score
Non Fat Milk Powder – NIST 1549	3.4 ± 0.1 (5)	3.38 ± 0.02	–1
Whole Milk Powder – NIST 8435	2.3 ± 0.4 (4)	2.3 ± 0.4	0
Typical Diet – NIST 1548a	0.741 ± 0.09 (4)	0.759 ± 0.103	–0.17

(*n*): Number of individual determination.

Table 2. Iodine concentrations in table salt samples by ENAA (in mg/kg)

Sample	Type	Origin	Average ± SD*
Brand 1	Refined	Limeira/SP	27 ± 1
Brand 2	Refined	Cabo Frio/RJ	53 ± 1
Brand 3	Refined/light	Cabo Frio/RJ	65 ± 4
Brand 4	Refined/light	Cabo Frio/RJ	37 ± 3
Brand 5	Non refined/light	Limeira/SP	24 ± 4
Brand 6	Refined	Asa Branca/RN	46 ± 4
Brand 7	Refined	Asa Branca/RN	25 ± 5
Brand 8	Refined	Asa Branca/RN	45 ± 6
Brand 9	Refined	Asa Branca/RN	30 ± 1
Brand 10	Refined	Asa Branca/RN	51 ± 9

* Average and standard deviation of three determinations.

Table 3. Results of iodine concentration and daily dietary ingestion in duplicate diet samples

Diet sample	Iodine concentration, average ± SD, mg/kg	Daily dietary ingestion, μg/day
DT1	1.8 ± 0.1	816
DT2	2.01 ± 0.04	674
DT3	1.9 ± 0.2	1020
DT4	1.6 ± 0.1	870
DT5	1.3 ± 0.2	581
DT6	1.65 ± 0.09	946
DT7	1.70 ± 0.06	774
DT8	1.44 ± 0.03	427
DT9	1.48 ± 0.05	633
DT10	1.5 ± 0.1	1059
DT11	1.6 ± 0.1	1004
DT12	1.56 ± 0.09	839
DT13	1.6 ± 0.1	623
DT14	1.45 ± 0.09	866
DT15	2.2 ± 0.2	1363
DT16	1.29 ± 0.09	617
DT17	1.7 ± 0.2	402
DT18	1.50 ± 0.07	770
DT19	1.85 ± 0.09	965
DT20	1.7 ± 0.1	784
DT21	1.6 ± 0.1	736
DT22	1.9 ± 0.2	628
DT23	1.9 ± 0.2	791
DT24	2.1 ± 0.2	869
DT25	2.1 ± 0.2	1256
Mean:	1.70	813
Range:	1.29–2.16	402–1363

Conclusions

ENAA technique has proved to be fast, precise and accurate to determine iodine in food samples. The daily dietary intakes of iodine obtained in this study showed to be excessive and suggest that further studies are needed to evaluate the ingestion of iodine through diets, as well as, clinical evaluations.

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