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Studies on iodine content in daily diets and selected dairy products

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Abstract Poland’s people have moderate – and in seaside areas mild – degrees of severity of iodine deficiency. A national program has been introduced for obligatory iodine prophylaxis and includes the iodination of household salt to the extent of 30±10 mg KI/kg. In order to assess the extent of iodine consumption, analytical studies were carried out on iodine content in average Polish diets. Taking into account the fact that milk formulae are frequently the basic source of iodine for infants, studies were performed on the iodine content in selected dairy products, mainly infant formulae. Iodine concentrations in samples were determined in duplicate by radioactive neutron activation analysis (RNAA). The iodine content in Polish diets without added iodinated kitchen salt was low and insufficient to provide the Polish RDA for this element. The results of the analytical investigations of the daily diets showed higher iodine content in comparison to theoretical calculations. The theoretical values accounted for 71–85% of the analytical ones. Study of iodine content in infant formula demonstrated differences between the analytically determined iodine content in products and that declared by producers.

Key words Iodine · Daily diets · Dairy products

Introduction

Iodine is a microelement essential for the normal development and functioning of humans, and is necessary for the synthesis of thyroid hormones. To ensure the normal growth and development of children, and for the maintenance of health, regular iodine intake is needed.

Iodine deficiency has been regarded by the World Health Organization (WHO) and United Nations Children’s Fund (UNICEF) as one of the most important nutritional factors which exerts a decisive influence on the health condition of a population, particularly children at all stages of their development. Frequent consequences of iodine deficiency are endemic goitre, hypothyroidism, retarded mental and physical development, and reproduction disturbances [1–3]. The main cause of low iodine intake is the low iodine content in food and low levels in drinking water.

Nutritional standards for the Polish population recommend consumption with daily diet of the following iodine amounts: 40 µg for infants up to 6 months, 50 µg from 6 months to one year, 70 µg for children aged from one to three years, and about 90–160 µg for older children and adults. Pregnant women should have 180 µg iodine daily and lactating women 200 µg iodine [4]. It should be stressed that the International Council for Control of Iodine Deficiency Disorders (ICCIDD) recommendations, presented after 1992, give higher values for infants and small children (90 µg iodine daily) [5, 6].

Studies on iodine deficiency in Poland, based on urinary iodine concentration and thyroid volume measurements, have revealed that over 80% of school children aged 6–13 years excrete less than 100 µg of iodine/day while normal values are 100–150 µg, and over 80% of pregnant women excrete less than 100 µg of iodine/day while the values accepted as normal are 200–250 µg. According to the ICCIDD criteria, the population of Poland suffers from moderate and, in coastal regions, mild degrees of severity of iodine deficiency [6, 7].

In view of the widespread occurrence of iodine deficiency in Poland, a national program has been introduced of obligatory iodine prophylaxis, including

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the iodination of kitchen salt to the extent of $30 \pm 10$ mg KI/kg [8], to achieve an average of 2.3 mg I/100 g of salt. The general system of iodine prophylaxis, based on obligatory iodination of salt for direct consumption, makes possible the provision of adequate amounts of iodine for the whole population, with the exception of pregnant and lactating women and infants.

Iodine deficiency produces a special health risk for new-born babies, infants and children. In the case of naturally fed infants, an effective method of providing an appropriate iodine intake is to supplement iodine into the diet of breast-feeding mothers. In the case of artificial feeding of infants, it is necessary to provide appropriate iodine concentrations in milk products for infants. According to the opinions of experts, enrichment of infant formulae with iodine should be at the level of 10 $\mu$g I/100 ml in milk formulae for healthy infants and 20 $\mu$g I/100 ml in milk formulae for premature new-born babies [9].

Within the present context of the iodine deficiency prophylaxis programme, it seems reasonable to conduct studies on the levels of iodine consumption in Poland. In this context, it is important to examine the diets typical of the Polish population.

In order to assess the extent of iodine consumption, analytical studies were carried out on iodine content in average Polish diets. The results of the analytical studies allowed for verification of the calculated assessment of iodine content in average Polish diets.

Taking into account that milk formulae are frequently the basic source of iodine for infants, and that infants are particularly sensitive to iodine deficiencies, studies were performed on the iodine content in selected dairy products, mainly milk formulae for infants.

### Materials and methods

Representative average Polish diets were prepared under laboratory conditions in the Department of Nutritional Value of Food, National Food and Nutrition Institute, Warsaw, from 80 food products purchased from Warsaw food markets. The quantities of products used for any given diet corresponded to the data of the household budgets reported by the Polish Central Statistical Bureau (PCSB) in 1996. The typical culinary methods to prepare food were used (for example, boiled potatoes, fried meat or eggs etc.). The detailed preparation of the diets is described elsewhere [10]. During preparation no addition of kitchen salt to the food was made.

The household budget data were used to distinguish among different groups of the population.

Diets on the basis of food intake data for following groups were chosen:
- Diet R1 – for blue collar workers, low income
- Diet R2 – for blue collar workers, medium income
- Diet NR1 – for white collar workers, low income
- Diet NR2 – for white collar workers, medium income
- Diet NZ – for unemployed people

Analysis of iodine content in six samples of dairy products purchased in the market (five samples of infant formulae and milk in granules with less fat) was also performed. Analytical studies of iodine content in Polish average diets and dairy products were conducted in the Department of Environmental Sciences, J. Stefan Institute in Ljubljana, Slovenia. Iodine concentrations in samples were determined in duplicate by radioactive neutron activation analysis (R NAA) as described elsewhere [11].

The samples of average diets were previously homogenized and then frozen and lyophilized in order to remove water (samples of milk products did not require this procedure).

### Irradiation of samples and standards

Depending on the quantity of iodine in the sample, homogenized and lyophilized samples (150–400 mg) and an appropriate aliquot of standard solution (10 mg/kg of I) in 5% solution of NH$_4$ were sealed in plastic tubes and irradiated simultaneously for approximately 1–25 min in the pneumatic transfer system of our TRIGA Mark II Reactor at a neutron fluence of $4 \times 10^{12}$ n/cm$^2$/s.

### Radiochemical separation of $^{128}$I

The separation procedure employed for this purpose is based upon combustion of the sample in the presence of carrier (50 mg/g of I) in an oxygen atmosphere (4-l Schöniger flask) followed by double extraction of I$_2$ with CCl$_4$ after the use of classical redox reactions with NaNO$_2$ and Na$_2$SO$_3$ in H$_2$SO$_4$ medium. The isolation procedure for $^{125}$I takes about 20 min.

### Measurement of $\gamma$-activity

The $\gamma$-activity of the isolated $^{128}$I nuclide ($^{127}$I (n, $\gamma$) $^{128}$I, $(1/2 = 25$ min; $E\gamma = 0.443$ MeV) was measured with a coaxial HP Ge detector connected to a 4096-channel Canberra 90 analyser, or a well-type HP Ge detector.

### Chemical yield

The chemical yield, which is mostly between 80–95%, was determined spectrophotometrically for each sample from the absorption of elemental iodine carrier in CCl$_4$ at 517 nm after $\gamma$-activity measurement.

A theoretical assessment was performed of iodine content using the same data for food consumption, which had served for reconstitution of diets in the Department of Nutritional Value of Food, National Food and Nutrition Institute. The calculation was done on the basis of data contained in the annex – Tables of Nutritional Values of Food Products [12].

The results of iodine content obtained were compared with weighted mean recommended daily intake of this element. These standards were calculated taking into account the demographic structure in the studied household types given by the PCSB and on the basis of the Recommended Dietary Allowances for the Polish population [4].

### Results and discussion

#### Study of iodine content in diets

The accuracy and reproducibility of the analytical procedure was examined with an analysis of certified reference materials. For the NIST Total diet 1548 and Milk powder 1549 values of $0.362 \pm 0.058$ µg/g and $3.37 \pm 0.09$ µg/g were obtained for four replicates,