



DISTRIBUTION OF IODINE AND SELENIUM IN SELECTED FOOD COMMODITIES

Strapáč, I.¹, Baranová, M.²

¹Department of Chemistry, Biochemistry and Biophysics, Institute of pharmaceutical chemistry

²Department of Food Hygiene and Technology, Institute of milk hygiene and technology
University of Veterinary Medicine and Pharmacy, Komenského 73, 041 81 Košice
The Slovak Republic

imrich.strapac@uvlf.sk

ABSTRACT

The aim of this study was to investigate the distribution of the contents of iodine and selenium in selected food commodities. Fresh food commodities were mineralized and analysed for their iodine and selenium content by Inductively Coupled Plasma-Mass Spectrometry using the calibration curve as the method for determining the contents of the elements. The average fruit and vegetables concentrations of iodine were very low. The cow's milk, other dairy products, eggs, poultry, fresh water fish, beef, liver, and mushrooms are frequently regarded as the most important natural source of dietary iodine from common foods. The higher concentrations of selenium were recorded in the kidney, liver, pork, beef, poultry, fresh water fish, hen's eggs, cow's milk, other dairy products, wheat flour, fats, coffee, peppers, mushrooms and potatoes.

Key words: food commodities; Inductively Coupled Plasma-Mass Spectrometry; iodine; selenium

INTRODUCTION

The living cell is a colloidal suspension of the elements surrounded by a semipermeable membrane, which enables the exchange of mass and energy with the immediate environment, which is closely related to its auto reproduction. For the proper functioning of a living organism, it must have the so-called essential trace elements that are involved in the life cycle of the cells. Iodine and selenium are included in the group of essential trace elements. They participate in the management of important biochemical processes. Deficient or excess intake of iodine and selenium leads to disorders of the body.

Iodine belongs to the main group in the periodic table of the trace elements called halogens. In the valence sphere, iodine has seven electrons $(5s)^2(5p)^5$. It lacks one electron to obtain an octet. By receiving one electron, iodine forms a stable iodide anion and obtains the configuration of the nearest inert element, xenon. Grey to black crystals of iodine easily sublime as a purple vapour. Free iodine is not found in nature. Iodine is present in the Earth's crust in the amount of 1.10—4% [6]. It can be found in the form of

iodides, or iodates ($\text{Ca}(\text{IO}_3)_2$) in Chilean saltpetre and as periodates which are found in minerals and rocks which are released by weathering. Subsequently, rain water washes them into the rivers, seas and oceans. It accumulates in seaweeds, corals, fishes, crabs and many other animals and plants.

The major part of the essential iodine enters into the human body via food and food products. As per the World Health Organization [16] recommendation, the safe and adequate dietary intake of iodine for infants to adults ranges from 50 to 200 μg per day. Iodine, as one of the trace elements, is required for the production of thyroxine $\text{T}_4(3,5,3',5'$ -tetraiodothyronine) and triiodothyronine $\text{T}_3(3,5,3'$ -triiodothyronine) hormones for the proper growth and development of the human body. Iodine deficiency causes severe disorders like cretinism, mental retardation and its excessive intake can lead to thyroiditis [1].

Selenium belongs to the sixth main group of the periodic table of the elements commonly called chalcogens (yield-forming elements). In the valence sphere, it has six electrons ($4s^2(4p)^4$). It lacks two electrons to obtain an octet. By receiving two electrons, selenium forms a stable anion Se^{2-} . In nature, selenium is present in the form of selenides accompanying sulphides.

Selenium is highly toxic for the human body, but in essential concentrations, it is very important for human life. The safe and adequate dietary intake of selenium for infants to adults ranges from 50 to 200 μg per day [16]. The optimum Daily Value (DV) for selenium intake is 1 $\mu\text{g.kg}^{-1}$ [13].

Selenium, primarily known for its antioxidant, anti-inflammatory and antiviral properties [8, 11], is an essential trace mineral for normal growth and development in livestock and humans. Selenium exerts its biological functions as a component of at least three groups of proteins: glutathione peroxidase that is responsible for the reduction of hydroperoxides in cells, plasma and gastrointestinal tract; the iodothyronine deiodinases, responsible for the peripheral deiodinates of thyroxine (T_4) to 3,5,3' triiodothyronine (T_3) and other metabolites; and thioredoxin reductases, which are involved in many cell functions, including the control of apoptosis and maintenance of the cellular redox state [12]. Selenium is present there as selenocysteine, selenomethionine and methylselenocysteine [3].

Selenium has an important role in human nutrition. The potential health benefits of dietary selenium includes improved immune response and thyroid function, as well

as cancer chemoprevention. The importance of selenium to humans and livestock is described in detail in the study by Palmieri and Szarek [10].

The aim of this study was to investigate the distribution of iodine and selenium content in selected food commodities available in Slovakia.

MATERIALS AND METHODS

As experimental materials, we used food commodities which were delivered for analysis to the State Veterinary and Food Institute in Kosice. The samples included commonly consumed foods of vegetable and animal origin (Table 1 and 2). The reagents used were of the highest quality (Suprapur and p.a). Water was purified and deionised. Before the analysis, samples were mineralized with 65% HNO_3 (Merck, Germany) in the microwave equipment MWS-2 BERGHOF (Germany). The weight of the samples were about 0.3 to 1.0 g of fresh weight (FW) or dried weight (DW) material. The final volume of the samples was 25 ml. Samples were analysed on an ICP-MS Agilent 7500C (USA) by accredited methods at the State Veterinary and Food Institute in Kosice. Iodine and selenium contents in mg.kg^{-1} were obtained from the calibration curves.

RESULTS AND DISCUSSION

The concentration levels of iodine and selenium measured in dry (DW) or fresh (FW) matter of food commodities are summarized in Tables 1 and 2 and in Fig. 1. The concentrations of iodine and selenium in the foods examined in this study were very low. This was probably caused by the low concentrations of these trace elements in the soil [6].

Higher values of iodine were found in milk and milk products and in hen's eggs (Table.1). The highest mean value of iodine was found in curds (0.382 mg.kg^{-1}). Lower mean values of iodine were found in cream cheese (0.278 mg.kg^{-1}), butter (0.150 mg.kg^{-1}), and fresh cow's milk (0.143 mg.kg^{-1}). The mean value of iodine in fresh cow's milk (0.143 mg.kg^{-1}) was lower in comparison to the published values [14] and ranged from 68.6 $\mu\text{g.l}^{-1}$ to 1000.6 $\mu\text{g.l}^{-1}$. Bhagat et al. [1] found $0.20 \pm 0.01 \text{ mg.kg}^{-1}$ of iodine in skimmed cow's milk. The values of iodine and selenium in cow's milk mostly depend on the quality of feedstuffs and on the supplementa-

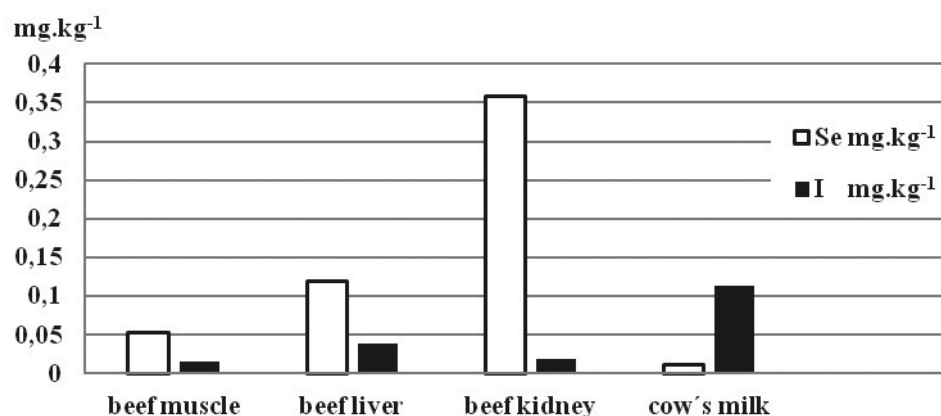


Fig. 1. Accumulation of selenium and iodine in beef muscle, liver, kidney and milk

tion of mineral additives which can increase the content of trace elements in milk [5]. Similarly, we were able to obtain eggs with higher values of selenium and iodine [15].

The iodine and selenium content of plant foods varied from species to species (Table 2). The mean iodine content in fruit (apple) and vegetables (onion, carrot, cabbage, tomato, potato) from domestic production was 0.001 mg.kg⁻¹ FW. The mean selenium content in the commodities was also low and varied from 0.007 mg.kg⁻¹ (cabbage) FW to 0.021 mg.kg⁻¹ (potato) FW.

A higher mean value of iodine was detected in green pepper (*Capsicum annum*) (0.093 mg.kg⁻¹ FW), and of selenium in oranges 0.258 mg.kg⁻¹ FW). Haldimann et al. [4] determined the iodine content in fresh fruit in the range of 2 to 75 ng.g⁻¹ DW and in samples of fresh vegetables in the range of 9 to 203 ng.g⁻¹ DW.

In the samples of mushrooms (Table 2), the mean iodine content was between 0.007 mg.kg⁻¹ (Shiitake – *Lentinula edodes*) and 0.027 mg.kg⁻¹ (Oyster mushroom – *Pleurotus ostreatus*). Haldiman et al. [4] determined the iodine content in mushrooms to be in the range of 44 to 426 ng.g⁻¹ DW.

The highest level of selenium in mushrooms was found in Parasol mushroom (*Macrolepiota procera*) (0.052 mg.kg⁻¹ DW). The concentrations of selenium in the samples of mushrooms corresponded to the published values of selenium in edible mushrooms. Falandyisz [3] found that the content of selenium in edible mushrooms was in a range from 5 µg.g⁻¹ DW (*Lycoperdon*, *Lycoperdon* spp.) to 370 µg.g⁻¹ DW (*Scutiger pes-caprae*, *Albatrellus pes-caprae*). A particularly rich source of selenium could be found in the seleni-

um-enriched mushrooms that are cultivated on a substrate fortified with selenium (as inorganic salt or selenized yeast). The selenium-enriched Champignon mushroom (*Agaricus bisporus*) can contain up to 30 or 110 µgSe.g⁻¹ DW [3].

Pork fat, butter and vegetable oil had almost the same values of selenium (Table 1); 0.074 mg.kg⁻¹ FW on average. The mean iodine content in these fats, varied from 0.005 mg.kg⁻¹ in vegetable oil, to 0.15 mg.kg⁻¹ in butter.

The mean iodine content in skeletal muscles (Table 1) varied between 0.005 mg.kg⁻¹ FW (wild boar, *Sus scrofa*) to 0.057 mg.kg⁻¹ FW (chicken breast). The higher mean iodine (0.057 mg.kg⁻¹) and selenium (0.108 mg.kg⁻¹) values in chicken breasts and hen's eggs (0.341 mg I.kg⁻¹ and 0.115 mg Se.kg⁻¹) were probably the result of iodine and selenium enriched mineral additives used to feed the chickens. Travnicek et al., [15] reported on the iodine content in consumer eggs. In the Czech Republic, 1 egg from a large flocks contained, on average, 31.2 µg iodine, while 1 egg from small flocks contained 10 µg.

The selenium content in the meat of farm animals was higher than in the meat of wild animals (Table 1). The selenium content in pork was 5.7 times higher than in the meat of wild boar (*Sus scrofa*) and the selenium content in beef was 3.1 times higher than in the meat of roe deer (*Capreolus capreolus*), and 6.9 times higher than in the meat of the red deer (*Cervus elaphus*).

Kursa et al. [7] evaluated the iodine and selenium contents in the skeletal muscles of red deer (*Cervus elaphus*), roe deer (*Capreolu scapreolus*) and wild boar (*Sus scrofa*) in the western and southern regions of the Czech Republic and in the Protected Landscape Area Šumava with a low content

Table 1. Mean content of selenium and iodine in food commodities of animal origin
(n = 3, with the exception of commodities marked with*)

Food commodities	FW/DW	Selenium [mg.kg ⁻¹]	SD	Iodine [mg.kg ⁻¹]	SD
Cow's milk	FW	0.027	0.0198	0.143	0.0776
Cream cheese	FW	0.108	0.0552	0.278	0.0566
Curds	FW	0.071	0.0176	0.382	0.3358
Butter	FW	0.072	0.0181	0.150	0.0694
Pork (muscle)	FW	0.160	0.0395	0.007	0.0050
Beef (muscle)	FW	0.096	0.0257	0.010	0.0009
Chicken breast	FW	0.108	0.0905	0.057	0.0001
Rabbit (muscle)	FW	0.049	–	0.006	–
Wild boar (muscle)	FW	0.028	0.0073	0.005	0.0013
Red deer (muscle)	FW	0.014	0.0037	0.021	0.0263
Roe deer (muscle)	FW	0.031	0.0160	0.008	0.0017
Freshwater fishes	FW	0.117	0.0347	0.049	0.0005
*Beef (liver)	FW	0.120	–	0.039	–
*Rabbit (liver)	FW	0.214	–	0.006	–
Wild boar (liver)	FW	0.063	0.0290	0.013	0.0001
*Red deer (liver)	FW	0.022	–	0.032	–
Roe deer (liver)	FW	0.075	0.0424	0.012	0.0005
*Hen (liver)	DW	0.168	–	0.018	–
*Beef kidney	FW	0.358	–	0.018	–
Pork (fat)	FW	0.080	0.0419	0.023	0.0111
Hen egg	FW	0.115	0.0880	0.341	0.2320

FW or DW — measured in dry (DW) or fresh (FW) matter; * — only one sample was examined

of iodine and selenium in the water and soil. In red deer muscles, the mean iodine content was $44.9 \pm 15.2 \mu\text{g.kg}^{-1}$ FW, ranging from 6.9 to $82.0 \mu\text{g.kg}^{-1}$. The lower concentration in roe deer meat (mean $39.3 \pm 14.1 \mu\text{g.kg}^{-1}$; range 18.3— $84.4 \mu\text{g.kg}^{-1}$) may have been due to the difference between biotopes and food. The mean iodine concentration in the *Musculus gracilis* of wild boars was $55.9 \pm 27.0 \mu\text{g.kg}^{-1}$ FW. The mean values of selenium content in the meat of red deer, roe deer and wild boars were 16.2 ± 8.4 , 36.9 ± 16.6 and $27.6 \pm 19.8 \mu\text{g.kg}^{-1}$ FW, respectively.

Our results were within the range of the above results. The highest content of selenium was found in rabbit liver

and a minimum content was determined in red deer liver. The content of selenium in beef liver was 5.5 times higher than the content of selenium in red deer liver and 1.6 times higher than the content of selenium in the roe deer liver (Table 1). The highest content of iodine was found in beef liver (0.039 mg.kg^{-1} FW). A similar mean value of iodine (0.032 mg.kg^{-1} FW) was found in the liver of red deer. The lowest mean values of iodine were determined in the liver of roe deer (0.012 mg.kg^{-1} FW) and wild boar (0.013 mg.kg^{-1} FW).

Table 1 shows also the mean values of selenium and iodine in the muscle tissue of freshwater fish. The content of

Table 2. Mean content of selenium and iodine in food commodities of vegetable origin
(n = 3, with the exception of commodities marked with*)

Food commodities	FW/DW	Selenium [mg.kg ⁻¹]	SD	Iodine [mg.kg ⁻¹]	SD
Onion	FW	0.019	0.0148	0.001	0.0007
Carrot	FW	0.009	0.0005	0.001	0.0009
Cabbage	FW	0.007	0.0025	0.001	0.0001
Tomato	FW	0.008	0.0037	0.001	0.0002
Green pepper	DW	0.039	0.0176	0.093	0.1232
Chilli pepper	DW	0.021	0.0067	0.016	0.0109
Potato	FW	0.021	0.0254	0.001	0.0004
Apple	FW	0.008	0.0012	0.001	0.0001
Orange	FW	0.258	0.4341	0.001	0.0006
Baby food	FW	0.007	0.0043	0.002	0.0023
Apple juice	FW	0.013	0.0100	0.001	0.0001
Champignon mushroom	DW	0.016	0.0057	0.016	0.0066
Oyster mushroom	DW	0.027	0.0137	0.027	0.0251
*Shiitake	DW	0.017	–	0.007	–
*Armillaria mellea	DW	0.018	–	0.013	–
*Parasol mushroom	DW	0.052	–	0.022	–
Beer	FW	0.017	0.0062	0.001	0.0001
Wine	FW	0.014	0.0156	0.002	0.0007
Coffee	DW	0.055	0.0042	0.001	0.0001
Rice	DW	0.018	0.0060	0.002	0.0005
Wheat flour	FW	0.104	0.0950	0.009	0.0007
Vegetable oil	FW	0.070	0.0476	0.005	0.0052

FW or DW — measured in dry (DW) or fresh (FW) matter; * — only one sample was examined

these elements in the muscle tissue depends on the species, age and weight of the fish. It is known, from the literature, that the content of iodine in the muscles of freshwater fish is 5 to 10 times lower than that in the muscles of saltwater fish [2, 4].

The comparison of the accumulation of selenium and iodine in beef, beef liver and kidney and in cow's milk evidently shows that most selenium accumulates in the kidney, less in the liver and in meat and the least in cow's milk (Fig. 1).

The maximum of iodine is accumulated in cow's milk and the minimum of iodine is accumulated in meat. Similar results were reported by Mehdi et al. [9] for bulls fed

with selenium enriched feedstuffs. The maximum of selenium was accumulated in kidneys, less in liver and the least in muscle tissue. So the offal of animals fed with a diet supplemented with the essential trace minerals are a good source of these substances for human nutrition.

CONCLUSIONS

This study provided information on the distribution of iodine and selenium in food commodities that are part of the daily diet of people. The determination of iodine in

food has been a challenging analytical problem for a long time. The concentration of iodine in most foods is too low. Iodine deficiency can be controlled through the fortification of food and food products with added iodine. The basic source of iodine is iodized salt, but people with a salt-free diet must look for alternative sources of iodine. An alternative source of iodine could be domestic foods, such as: curds, chicken eggs, cream cheese, cow's milk, pepper, chicken breasts, freshwater fish, offal and mushrooms. Very low concentrations of iodine were detected in the samples of fruits, vegetables and beverages.

The highest value of selenium was accumulated in animal offal (kidneys and liver). Acceptable concentrations of selenium were found in pork, chicken breasts, freshwater fishes, milk and milk products, in wheat flour, fats, coffee, green pepper, mushrooms and potatoes.

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