

Iodine: An Essential Trace Element

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Mini Review

Volume 2 Issue 4

Received Date: July 26, 2018

Published Date: August 20, 2018

DOI: 10.23880/mjccs-16000171

Abstract

Iodine is an important trace element for health. This element is found in nature, mostly in the marine environment, where it accumulates in marine organisms. The diet is the main source of iodine, being foods of marine origin such as seaweed or shellfish that represent a greater dietary contribution. A deficit intake of this element can lead to serious effects such as hypothyroidism, goiter or cretinism. However, excessive intake of this element may result in hyperthyroidism, thyroid cancer, among other effects. The new trends in food have caused an increase in the consumption of food, as these are one of the most important sources of iodine can pose to health risk, in cases of excessive consumption of algae.

Keywords: Iodine; Dietary Intake; Hyperthyroidism; Toxic Risk

Abbreviations: RDI: Recommended Daily Intake; EFSA: European Food Safety Authority; ADI: Admissible Daily Intake.

Introduction

Iodine (I) with a molecular weight of 126.9 g/mol is a non-metal belonging to the group of halogens. As an element of high electro negativity, it is widely distributed in nature, especially its concentrations in the marine environment, where it can reach levels around 50 - 60 µg/L of sea water [1]. It can be found in three different ionic forms due to its oxidation states. The most frequent one in marine waters is iodide (I⁻) whose oxidation state is 1⁻; generally, it is found forming salts such as potassium iodide (KI) or sodium iodide (NaI). Also, it can be found

as iodates (IO₃⁻, IO₄⁻), whose oxidation states are 5⁺ and 7⁺.

Iodine is an essential trace element for humans [2]. This element is necessary because it is part of the hormones of the thyroid [3]. Iodine deficiency in the body can lead to serious problems such as hypothyroidism, cretinism, goiter, etc [3]. The EFSA (European Food Safety Authority) has set a recommended daily intake (RDI) of 150 µg/day for adults [4].

However, excess iodine can cause both hypothyroidism and hyperthyroidism. Likewise, the American institution Institute of Medicine has established a value of admissible daily intake (ADI) of 1100 µg/day for adults [5].

An adequate intake of iodine is necessary for the proper functioning of the thyroid gland and, therefore, to maintain normal levels of thyroid hormones. In some countries for this reason, the use of iodized salts has been resorted to in order to cover the daily iodine requirements [6,7].

Iodine Chemistry

Iodine (I), of atomic number 53, is an element belonging to the group of halogens. Its atomic mass is 126.9 Da and its oxidation states are 1-, 1+, 3+, 5+ and 7+. It is one of the most stable elements of the group of halogens due to its low electro negativity, which is 2.66 on the Pauling scale, whose value is lower compared to fluorine which is 3.98. Like the rest of the elements belonging to the group of halogens, iodine is found as a diatomic molecule, I₂. However, unlike the other halogens, iodine can be in the solid state, but it is volatile at room temperature. The electronic configuration of iodine is [Kr] 4d¹⁰5s²5p⁵. This configuration allows you to capture an electron to form a stable structure, for that reason, iodine tends to gain an electron [8].

Iodine Sources

Natural Sources

The release of iodine in the environment comes, mainly, from the leaching of soils. Soils and rocks of volcanic origin have higher iodine content [4]. When the leaching of soils and rocks occurs in marine sediments, the released iodine accumulates in marine organisms. The minerals in which iodine is found are iodargirite (AgI), marshite (CuI), bellingerite (Cu (IO₃)₂·2H₂O), among others [9].

Anthropogenic Sources

No anthropogenic sources are known of iodine [10]. Environmental pollution due to high iodine content is practically nonexistent. Mainly, this element is used in the pharmaceutical industry, photography and dyes. However, if it is known the environmental repercussion derived from the use of isotopes of iodine, especially iodine-129, whose half-life is 16 million years. Iodine-129 is a major environmental pollutant [11]. Its continued use since 1940 has caused a dangerous increase of this isotope in the environment, with a greater accumulation in surface and groundwater [12,13].

Distribution of iodine in the Environment

Iodine is found in the earth's crust at a concentration of approximately 0.14 mg/kg. While, the concentration of this element in the seawater is around 0.052 mg/L.

Iodine cycle in nature

As for the iodine cycle in nature, it is found naturally in the marine environment. The iodine is found in the marine soils as IO₃⁻, where is absorbed by the phytoplankton and reduced to I⁻. Then, the iodide is absorbed by seaweeds and transformed to I₂. Finally, is evaporated in the form of organic compounds of molecular iodine (I₂), which are then deposited in a terrestrial environment with rain.

Dietary sources of iodine

The main source of iodine is diet, with marine-based foods such as algae or seafood, which have the highest levels in this element [14,15]. In addition, cases of hyperthyroidism associated with high algae consumption have been detected [16].

Table 1 shows the average concentrations of iodine found in different types of food by Leufroy, et al. [17]. Shellfish and seaweed is the food group with the highest mean content of iodine which is normal because seawater contains the highest iodine levels.

Considering the iodine concentrations, the intake of seaweeds will contribute greatly to the recommended daily intake of iodine.

Food group	Number of samples	Iodine concentration (mg/kg dry weight)	Reference
Fruits	34	0.014	[17]
Green vegetables	11	0.427	
Shellfish	9	46.2	
Fish	41	1.57	
Seaweed (Kombu)	-	394	[18]
Seaweed (Wakame)	-	14	

Table 1: Iodine concentrations (mg/kg) in different food groups

Metabolism

Iodine, once ingested, is reduced in the intestine to iodide. Iodide is absorbed almost entirely by the small intestine. The absorption of iodide is around 90% of the total ingested [4]. Once absorbed, it passes into the blood and is distributed through the tissues, accumulating in the

thyroid glands, mostly. In healthy adults, with normal levels of iodine in the body, most of the ingested iodine is excreted with urine.

Importance in the Human Organism

Iodine is an essential element for the human being because it is part of the thyroid hormones (Figure 1) [16].

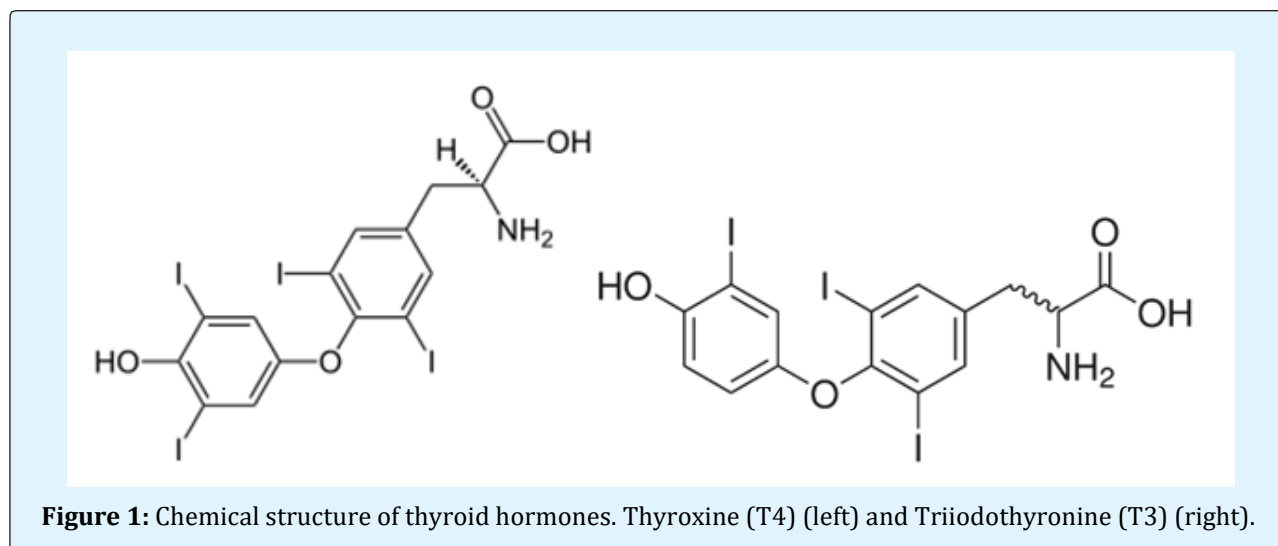


Figure 1: Chemical structure of thyroid hormones. Thyroxine (T4) (left) and Triiodothyronine (T3) (right).

A deficient iodine intake can cause serious problems such as hypothyroidism, cretinism, among others [3]. For this reason, various organizations such as the American institution "Institute of Medicine" or the European Food Safety Agency have set guide values for recommended daily intake of iodine, being 150 µg/day for adults [4,5].

The deficient iodine intake is a health public concern in certain areas of Europe. A solution to this problem is the fortification of some food with iodine as for example, the iodization of table salt.

However, excessive intake of iodine can produce an inhibition of the synthesis of thyroid hormones, as happens in cases of iodine deficiency. Also, it can lead to an excessive secretion of thyroid hormones, causing hyperthyroidism, goiter, hyperactivity, tachycardia, thyroid cancer, etc [19-21].

Conclusions

Iodine is an essential element necessary for the proper functioning of the thyroid. However, some diets such as vegans or vegetarians, based on the consumption of products such as algae, can pose a health risk due to a high intake of this element. It is necessary greater control in the levels of iodine in food from the sea to avoid high intakes.

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