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Mini Review

Edible Macroalgae: Beneficial Resource of Iodine

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Abstract

Iodine is an essential element required for the synthesis of thyroid hormones. Its deficiency is correlated to goiter, while in excess can cause autoimmune thyroiditis. Worldwide exists a deficiency in iodine, and recommended daily intake should be 150μg for adults. One of the most naturally available and abundant resources of iodine is macroalgae, which may contain it in several orders different concentrations, depends primarily on species. To accomplish the recommended daily intake of iodine, it is important to know the exact concentration of iodine in macroalgae, dried and/or processed.

Keywords: Iodine; Thyroid Hormones, Goiter; Hypothyroidism; Recommended Daily Intake; Natural Food Sources of Iodine; Macroalgae; Dried and processed Macro algae; Bioavailability

Introduction

Iodine is a trace element, the essential constituent of thyroid hormones, triiodothyronine (T3) and thyroxine (T4), both having an important role in cell metabolism, reproduction and growth [1-3]. Deficiency of iodine is associated with increased frequency of goiter, hypothyroidism, lack of strength and eventually, hypotension, lethargy and obesity [4,5]. On the other hand, excess iodine can cause autoimmune thyroiditis [6]. Insufficient iodine intake led to problems in different groups of the population worldwide and special attention should be taken for the commercial products that have no specified iodine content [7]. Following a request from the European Commission, after a large epidemiological study, the Panel of European Food Safety Authority (EFSA) proposed an adequate intake of iodine of 150μg/day for adults and 200μg/day for pregnant women [5,8]. In the USA, the recommended daily intake is 220μg and 290μg for pregnant and women in a period of lactation, respectively [9]. A significant part of the population in the world is with insufficient iodine intake [8,10]. The most affected regions are in Africa, Eastern Mediterranean and Europe, where it was estimated that the iodine intake of 42,6%, 54.1% and 56.9% of the general population, respectively [8]. According to the current estimate, the total goiter prevalence has been increased by 62.9% in Eastern Mediterranean countries, and for around 81% in Africa and Europe [8]. Overall, almost one-third of the population worldwide (31.7%) indicates insufficient iodine intake. These statistics clearly 2 pointed out a serious problem and as a solution, improved iodine nutrition may reflect better results in populations who are severely deficient. Since the strategy to use the salt iodization is known to be a highly cost-effective method of supplying iodine, and moreover, it may increase the risk of cardiovascular diseases, alternative resources of iodine have to be used [10,11]. The most abundant dietary resources of iodine are edible seafood and seaweeds, i.e., macroalgae that can quantitatively accumulate iodine from seawater [12]. Traditionally, most meals in Japan include soups with macroalgae and this is changing more towards more Western foods. In Japan, 21 species of macroalgae are included in the diet, in Hawaii and Polynesian islands more than 25 species are in use as food and medicine, whereas in Korea more than 40 kinds of macroalgae are applied in gastronomy [13]. Macroalgae are increasingly common food in the United States [14].

Macroalgae as a Source of Iodine

Rich in micronutrients, macroalgae contain also high levels of iodine and thus they are multipurpose as food supplements and nutraceuticals with potential health implications. Divided into three main taxonomic categories, macroalgae can be green (*Chlorophytae*), red (*Rhodophyceae*) and brown (*Phaeophytae*), each of them with different absorption potential for trace elements

from seawater, among others iodine [15,16]. In general, macroalgae are considered rich in iodine, but total iodine contents vary amongst species and taxonomic entities, and may depend on collection sites and season, and/or processing [14,17-21]. Some species, in particular, brown macroalgae, such as *Laminaria spp*. (Konbu) or *Laminariale spp*. (Kelp), can accumulate very high levels of iodine which plays a physiological role in oxidative and salinity stress responses [22-24].

Iodine Level in Macroalgae

The overall range of the iodine level in macroalgae is very broad, because they may contain from only a few ppm to several thousand ppm of iodine [7,12,20,25-31]. Brown *macroalga Laminaria sp*. is the best accumulator of iodine with its average content of almost 0.3% of dry weight, thus representing 104 more concentration of this element in comparison with seawater [12,26]. In studies in the lagoon of Venice, brown macroalgae species *Sargassum muticum* and *Undaria pinnatifida* (Wakame) collected from the depth at 50 cm, showed concentrations of 177ppm and 583ppm, per dry weight (dw), respectively [25]. Similarly, U. pinnatifida (Wakame) imported from Japan had iodine content equal to 260 ppm (dw), whereas *Laminaria digitata japonica* (Konbu) contained as much as 1700ppm (dw) of total iodine [27]. Considering the recommended daily intake of iodine, the consumption of 577mg of selected Japanese species of *U. pinnatifida* (Wakame) or 88mg of *L. digitata japonica* (Konbu) per day, would satisfy the established requirement for adults [5,8,9]. Concerning the Japanese species of Konbu, even 2-4 times higher values were found for the species of *Laminaria ochroleuca* (Konbu) harvested in the north-western Spanish coast, and they contained from 3703 to 7088ppm (dw) of iodine [28]. On the other hand, similarly to Japanese *macroalgae Laminaria spp*., Konbu from Taiwan showed an average iodine concentration of 2524ppm [29]. Species of brown *Saccharina latissima* from Lysefjord in Norway, showed different values of total iodine concentration, ranging from 380 to 3965ppm dw, which depended on the seasonal variation of sampling and geographical origin of the species [30]. Brown macroalgae belonging to *Laminariale spp*. (Kelp) were shown to be the richest natural source of iodine (up to 10203ppm, dw), whereas some red species of commercial macroalgae (e.g., *Chondrus crispus*) had two orders of concentration lower levels, i.e., 296ppm (dw) [20]. Red *macroalga Palmaria Palmata* from the North Atlantic was also rich in iodine, with its total content of 2149 ppm (dw) and it meets recommended intake by daily consumption of 70mg of dried species [31].

Besides dried macroalgae, the effect of the cooking process on iodine level was examined as well, and it was deduced that boiling can lead to changes in the total iodine concentration in macroalgae. As an example, boiling of dried *Saccharina spp*. for several minutes will result in the reduction of its iodine content to approximately one-third of the initial value and after boiling up to 30 min the result will remain the same [30]. During iodine change testing, after boiling of red *macroalga Palmaria palmata*, it was estimated that 68% of seaweed iodine remained, thus still representing a rich iodine source [32]. Moreover, it was established that iodine had moderate bioavailability (49-82%) after gastrointestinal digestion [33]. Therefore, the concerns over iodine intake from macroalgae and its bioavailability must be evaluated better, concerning all crucial parameters.

Conclusion

To overcome iodine deficiency one of the useful solutions is the consumption of macroalgae, which can provide the necessary daily intake recommended for each population group. Future research should explore in more detail, the iodine content (and bioavailability) after consumption of edible macroalgae, dried and/or processed by any recommended technique and thus, prove the beneficial effects of macroalgae in human health.

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Conflict of Interest

Authors declare that there is no financial interest or conflict of interest.

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