*Mini-Review*
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# Iodine important health nutrient: sources and method of detection in search of natural iodine resources

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**Abstract**
Iodine is a fourth member of the halogen family, found naturally in soil and marine water and vital for human beings as required to synthesize thyroid hormones for a sustainable metabolic pathway in humans. It is recommended that humans get iodine in the diet to avoid irregularities related to this thyroid hormone. Iodine is a nutrient element that which body cannot synthesize but need to consume from available natural or synthesized sources (iodine supplement). Otherwise, a deficiency may lead to hypothyroidism, consequently can perceive health-associated complications including bone joint pain, infertility in women, fatigue, etc. The current review article highlights the significance, sources, and methods of detecting iodine in plants and other natural resources to get information about the natural iodine contents.
**Keywords**: Iodine, human, significance, deficiencies, sources, methods

**Highlights**

- ✓ Significance of Iodine for human
- ✓ Iodine natural resources
- ✓ method of detection

## 1. Introduction

### 1.1 Habitat:

Iodine belongs to the seventh group of the periodic Table (Halogen), originates naturally in inorganic and organic forms, is an essential nutrient mineral required for human health, and is found in some foods. The human body's requirement for iodine is for the synthesis of thyroid hormones to control the body's metabolism related to the crucial functions of the human body. The body also needs thyroid hormones for appropriate bone and brain progress throughout pregnancy and initial stages. Receiving sufficient iodine is vital for everybody, particularly newborns, babies, toddlers, and females having pregnancy.

Due to the regularity of human health complications and inadequate consumption, new or extra sources of iodine should be investigated in which iodine enriched plants must be investigated as new resources of the iodine before introducing it as a health supplement. The relation of iodine to thyroid metabolism has been investigated worldwide. Still, there is a lack of information about iodine contents in foodstuff and herbal plants, which may be an iodine supplement for human intake. The concentration of iodine in the spices ranged from 21.56 ± 3.6 µg/100 g in garlic (*Allium sativum*) to 95.66 ± 1.73 µg/100 g in Uziza (*Piper guineense*). Furthermore, iodine was not detected in some of the plants sampled. This review emphasized sources and methods for the detection of iodine for providing adequate knowledge about proper intake of iodine in diet from natural resources.

### 1.2 Sources of Iodine

Usually, Iodine fortification is based on natural resources for adequate dietary intake worldwide. For this purpose, 70 % of countries use iodized salt in cooked meals worldwide. It usually serves as the primary source of iodine intake, where one-fourth of a teaspoon of iodized salts contains 100 micrograms of iodine (Błażewicz, 2012).. The iodide salt is the primary resource of iodine for cooked to intake by humans. Furthermore, various Seaweeds (like Kelp, Cod etc.), fish, Dairy milk, eggs, beef liver, and chicken are some of the sources of iodine that occur naturally. In contrast, breast milk is also a good resource for an infant's growth. Furthermore, iodine-rich soil is also a good resource for growing specific vegetables.

### 1.3 Iodine functioning in human

Transporters, a primitive electron donor via peroxidase enzymes, it has an inherited antioxidant function in all iodide-concentrating cells, from Sea algae to different current terrestrial vertebrates. Iodine ( ${}_{53}I^{126.9}$) is involved in the synthesis of thyroid hormones where two iodine containing-hormones, triiodothyronine (T3) and thyroxine (T4), are associated with the thyroid function. It is involved in the physiological role of thyroid hormones. Thyroid function is critical to the metabolism and directly links to iodide supply for approximately all tissues of the body; also very significant for developing the essential nervous system in the fetus and children (Braverman & Cooper,2012; Koronowicz et al., 2016; Landini et al. 2012)

## 2. Methods of detection of iodine

The relation of iodine to thyroid metabolism has been investigated worldwide. Still, there is a lack of information about Iodine contents in foodstuff and herbal plants, which may act as an Iodine supplement for human intake. A detailed literature search revealed that several methods are available for the detection of iodine; where these methods comprise extraction from plants, using reagents, precipitate formation, and application of advanced technologies to detect iodine in available sources (Jopke et al. 1996: Maichin et al. 1998. Some of the methods involve the collection of plants or animal tissues, washing, drying, weighing, and applications of the basic or latest technology (Fig. 1).

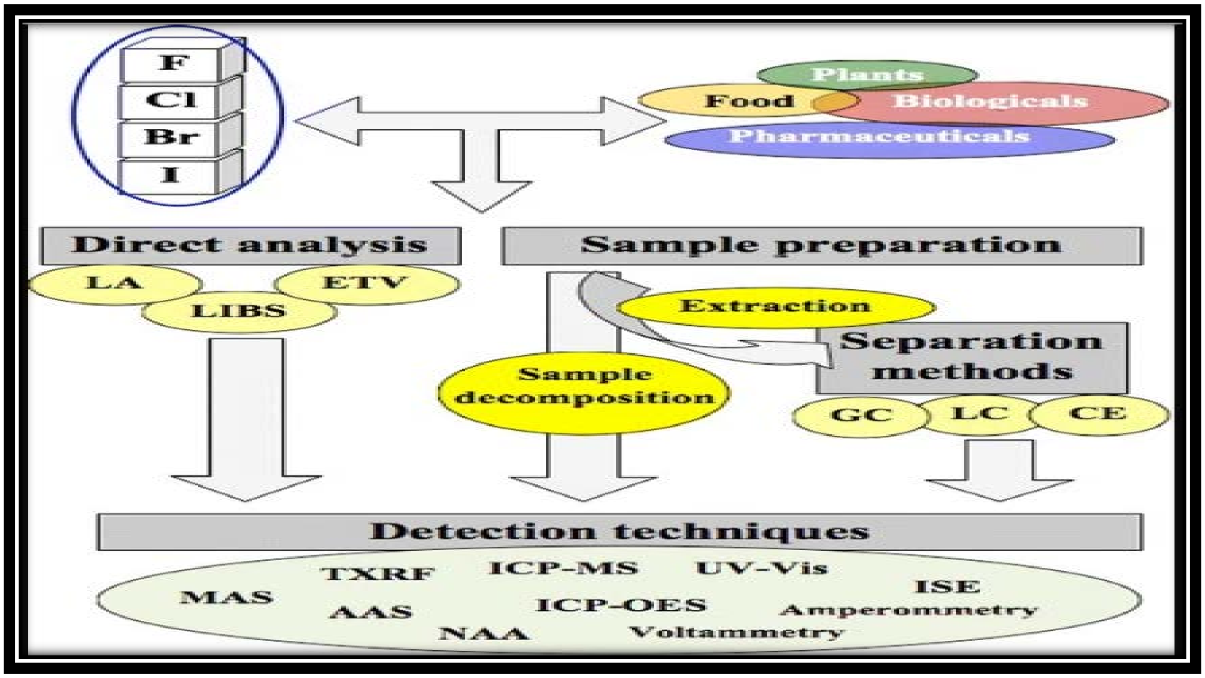


**Figure 1:** Analytical methods for quantification of iodine in the sample((Mello et al., 2013)

de Souza et al. (2016) determined iodine in the seawater through electrochemical methods where a comparison was conducted between amperometric and potentiometric detection using a modified carbon electrode. They observed that statistical analysis found the potentiometric method best over the amperometric method. The literature revealed other methods (Ryabukhina & Bazel 2018).) that can also be used to determine the concentration of several ions, including commercially available potentiometric electrochemical electrodes. These electrodes create a continuous-signal output voltage where the Nernst equation determines ion activity.

However, sometimes observed output voltage is not predictably related to the concentration of specific ions because i) the activity of the desired ion in a solution may be affected by the specific activities of other ions as the strength of the other ions increases; in due course, the movement of ions under observation decreases; ii) also ions in solution may be in the form of the complex; therefore, the restrained activity varies obviously from the concentration. For example, in the case of Seawater samples, the sensitivity of the electrode plays a significant role due to the presence of several types of ions or the complex nature of some metal ions. Monitoring of chemical precipitation through conductometrically is primarily used in determining the movement of ions under the influence of current. Haldiman et al. (2005)detected the iodine content through isotope dilution inductively coupled plasma mass spectrometry using the enriched long-lived nuclide $^{129}I_2$ in a urine sample where sample diluted with the $NH_3$ solution containing $^{129}I_2$ and results were validated by comparison through a spectrophotometric method based on the Sandroughell-Kolthoff reaction

Azmat et al.(2021), in their patents, used conductometric titration to determine the iodine in plants as the most straightforward technology, which could be an alternative technique in the earlier patents and research reports. It differs in the fact that an excess of the precipitating agent ($AgNO_3$) in the plant aqueous extract solution is used, that the concentration of the precipitating agent need not be predetermined, and that the measurements are made through specific conductivity rather than electrode potential. The obtained precipitated were analyzed by chemical testing and spectrophotometric method (Fig.2).

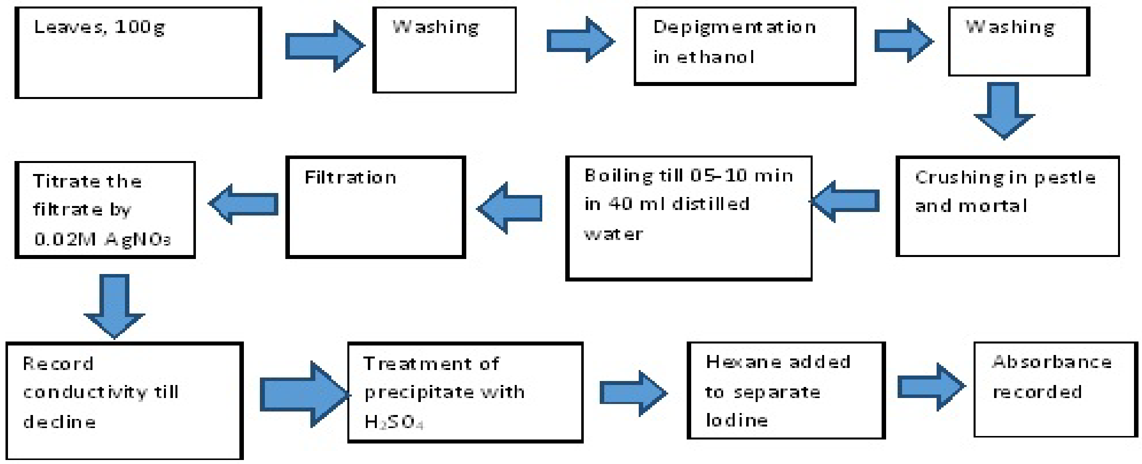


**Figure 2:** Analysis of the iodine in plants by conductometric titration (Azmat et al., 2021)

Ujowundu et al.2011 detected iodine in selected vegetables and spices, which showed that the mean iodine concentration of the vegetables was 94.61 ± 15.28 µg/100 g, with Uha leaves (*Pterocarpus* spp.) having the highest with 117.66 ± 3.00 µg/100 g iodine, cowpea (*Vigna sinensis*) had the highest mean iodine concentration of 69.36 ± 7.94 µg/100 g in grains. The concentration of iodine in the spices ranged from 21.56 ± 3.6 µg/100 g in garlic (*Allium sativum*) to 95.66 ± 1.73 µg/100 g in Uziza (*Piper guineense*), while iodine was not detected in some of the plants sampled. Haldimann et al.(2005) used isotope dilution inductively coupled plasma mass spectrometry using the enriched long-lived nuclide $^{129}I_2$ to detect iodide content in several foods. They reported significant dissimilarities in levels of iodine among solo foodstuffs inside food groups that applied to other food groups, also

Iodine in plants is determined by destroying organic matter using alkaline incineration and automated spectrophotometric determination of iodide based on Sandell and Kolthoff's reaction. The mean recovery of $^{131}I$ was 93.4% (S.D. = 3.19)). For replicate analyses of different plant materials, the coefficient of variation was between 3 and 5%. (Bellanger et al., 1975). Plant dry material is used to detect the iodine wherein radiochemical separation of iodine-128 using an alkaline fusion of the sample in the presence of an iodine carrier, followed by isolation of iodine by solvent extraction and a precipitation step. The precision of the method is about 5% at the 0.05 ppm level and 10% at the 0.005 ppm level of iodine (Johansen & Steinnes 1976).

Chromium trioxide as an oxidant is used to determine iodine in plant material wherein wet digestion followed by the distillation of iodine reduced from iodate with phosphorus. Iodine recovery from dried seaweeds (1 g) was found to be (9799)% (Kametani & Kawakami, 1980).

Gwarzo 2012. (2012) determined the iodine in the leaves of *Spinacia oleracea* L. (spinach), *Brassica olarecea* V. (cabbage), *Hibiscus sabdriffa* L. and *Lactuca sativa* L. (lettuce) where *Hibiscus sabdriffa* L He observed a high level of iodine (0.0043%) followed by highest moisture content (10.41%) in salad and cabbage with the highest ash content (6.35%). It indicates that consumption of these plants could serve as good food supplements for men and may assist in suppressing iodine deficiency disorders (IDD). Kaňa et al. (2015) reported the method of detecting iodine and iodine species using inductively coupled plasma mass spectrometry (ICP-MS). They reported inorganic and organic iodide contents from animal liver tissues and plant species. The ion-exchange chromatography (PRP X100, mobile phase 100 mmol $L^{-1}$ ammonium nitrate, pH 7.4) coupled with ICP-MS was used to determine the inorganic iodine species in plants and animal issues species, while the organic iodine species were separated using size-exclusion chromatography and also detected using ICP-MS. Samples of porcine muscle, liver, kidney and thyroid gland, chicken muscle and liver, and Atlantic Cod muscle were analyzed. Fordyce (2003) published a report related to iodine contents. He described that most of the iodine in western countries comes from other sources like iodophors in the dairy industry, red food coloring, and improvers in cereals, bread, meat, and sweets. He also described food-based classifications in which marine fish consists of the highest contents (1455.9 µg/kg) followed by Freshwater fish (102.8 µg/kg), while Leafy vegetables contain more (88.8 µg/kg) than Dairy meals

(83.9 μg/kg) and other vegetables (80.1 μg/kg). In this report he reported that Meat contain (68.4 μg/kg), Cereals (56.0 μg/kg) Fresh fruit (30.6 μg/kg), Bread (17.0 μg/kg) and Water (6.4 μg/l).

Tinggi et al.(2011) reported iodine nutritional status in some selected food items taken from local food market outlets in Brisbane, Australia. The analysis of iodine contents in various food samples was conducted using inductively coupled plasma-mass spectrometry (ICP-MS), where tetramethylammonium hydroxide (TMAH) was used for the alkaline digestion of the samples, followed by their validation in comparison to the certified reference material of nonfat milk (NIST, SRM1549). It was observed that iodine contents varied in food ranging from <0.02 to 0.101 mg/kg for cereals, 87 to 299 μg/kg for milk, and 86 to 271 μg/kg for cheese products.

Grass and crop samples are also used for iodine detection through decomposition in dilute digestion using sulphuric, nitric, and perchloric acid, which proves to be simple and faster for routine work (Pauwels 1962). Inductively coupled plasma mass spectrometry (ICP-MS) after alkaline microwave extraction was applied for iodine determination in some plant samples and compared with the independent method (k0-INAA). They showed excellent agreement, proving the accuracy of the determination by ICP-MS. A nuclear reaction with an epithermal neutron was used to determine 128I in foodstuff (Yusuf & Suprapti 2020). Ohno et al. (2013) developed a method for iodine (129I) detection in soil samples through a Triple Quadrupole ICP-MS, to investigate radioiodine released by the Fukushima Daiichi Nuclear Power Plant (FDNPP) accident. The determination of 129I by ICP-MS can provide a high sample throughput compared to other methods. Nonetheless, the high background caused by 129Xe impurities in argon plasma gas and polyatomic ions such as 127IH2+ and 127ID+ has made it difficult to carry out.

## 3. Conclusion:

It was concluded that iodine is essential for human health to synthesize thyroid hormone. There is a need to develop a more straightforward, innovative method to search for new iodine resources.

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