Women's Health Scientific Review Paper:
The Importance of Iodine & the Implications of Deficiency

Abstract

Iodine is an essential nutrient that is required throughout life for men and women. However, it plays a greater role in women's health generally and throughout life and can be needed in highly levels during specific times in the lives of many women such as pregnancy and breastfeeding. During this time, women are recommended to increase their daily intake to support the increased demand Despite this, recent data suggests that almost half of the all the women in the UK population could be classed as deficient, and that is without taking pregnant and breast-feeding women into consideration who it is suggested need additional iodine. Furthermore, the evidence shows that deficiency is highest amongst adolescent girls, which could indicate a life-long problem with sufficient iodine intake.

Iodine deficiency can be linked to a lack of iodine in the diet by not consuming sufficient sources of iodine, which primarily include white fish and dairy. Data indicates that there is a decline in women consuming white fish and dairy products than previous generations, and with a sharp rise in dairy alternatives which contain no natural iodine. Furthermore, plant-based, or vegan diets exclude these foods altogether and offer no good natural source of essential iodine.

Being deficient in iodine can result in an underactive thyroid, with common symptoms including weight gain, memory issues, tiredness, poor quality and brittle hair, nails, and skin.

Finding solutions to the increasing prevalence of iodine deficiency, and that can suit all dietary needs, thus addressing various aspects of women's health is extremely important. One natural solution is through the use of seaweeds as ingredients in foods, beverages, and nutrition products, as an iodine rich, vegan source. The right type of seaweed ingredients, from suitable sources is key, and a small addition can easily provide the reference nutrient intake for iodine of 140micrograms, allowing for several highly pertinent EU Approved Health Claims.

Iodine

Iodine is an essential mineral that is required by the body to be able to produce thyroid hormones[i]. These hormones have numerous roles within the body, including controlling aspects of the metabolic rate, which influences the speed at which cells

burn energy. The human body cannot create iodine and so adequate intake must be achieved through the diet.

The European Food Safety Authority (EFSA)[ii] and the World Health Organisation (WHO)[iii] recommend a daily intake of 150µg and an additional 50-100µg for women who are pregnant or are breastfeeding. Several developed countries in the world follow a universal salt iodinisation (USI) programme which fortifies table salt with iodine. This was implemented with the aim of addressing iodine deficiency through artificial fortification in a very cost-effective way. However, a number of countries do not follow the USI programme, including the UK. Furthermore, there is a decline in salt intake in developing countries due to health concerns linked to sodium, as well as some backlash against artificial supplementation.

The UK's reference nutrient intake (RNI) differs from EFSA and WHO and is slightly less at 140µg[iv]. There is also no recommendation for additional intake for pregnant and breast-feeding women. However, the data is disturbing with 62% of pregnant women in the UK being deficient according to studies[v] and suggests that the majority of pregnant women are not getting even 140µg.

Furthermore, data from the UK has demonstrate that teenage girls, pregnant women, and women aged 55 or more are at the highest risk of deficiency. These groups indicate that deficiency affects at least 50% of the population within these groups, with the highest being close to the 70% mark (Figure 1).

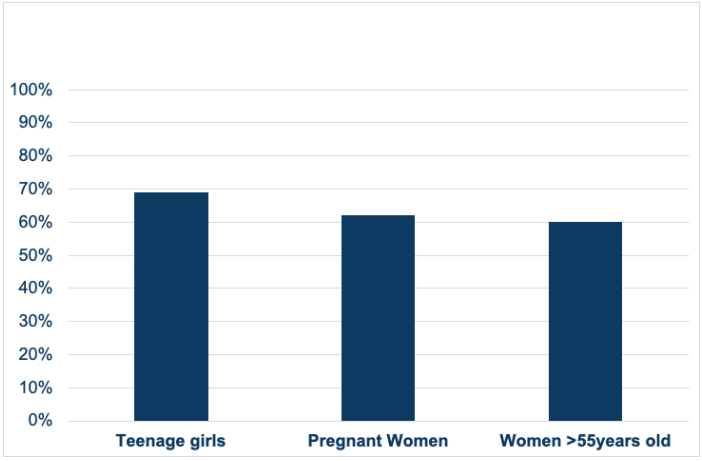

Figure 1. Percentage of teenage girls, pregnant women, and women over 55 who are deficient.

Thyroid & Women's Health

Iodine is essential for the production of thyroid hormones. The thyroid is a gland that is located in the neck, and rests either side of the windpipe. It is responsible for creating the hormones thyroxine (T4) and triiodothyronine (T3). These are named T3 and T4,

with the numbers representing how many iodine atoms each hormone contains[vi]. However, when the balance is affected, by having too much or too little iodine, it can lead to negative health effects. Women are more likely than men to have thyroid diseases, especially following pregnancy, and menopause[vii]. In fact, the UK's National Institute for Health and Care Excellence (NICE) states that women are 5 to 10 times more likely with the highest percentage of those women being aged 60+[viii].

When the thyroid is not producing sufficient hormones, it is known as hypothyroidism which is more commonly referred to as an underactive thyroid. There are various reasons why hypothyroidism can develop although it is often due to a diet that is insufficient in iodine. The symptoms of hypothyroidism are reported as feeling tired, gaining weight, feeling depressed, being sensitive to the cold, having dry and brittle hair and nails, and experiencing muscle aches[ix]. In extreme cases of severe deficiency (20µg or less iodine) a disorder called goitre can develop. This is where the thyroid tries to keep up with the demand for iodine but cannot due to a low dietary intake. As a response, the thyroid begins to swell in order to enable more blood to pass through it in an attempt to extract more iodine[x].

On the other hand, consuming too much iodine can also be an issue and this can cause hyperthyroidism, which is also known as having an overactive thyroid. This condition is 10 times more common in women than men and typically occurs between the ages of 20 and 40. The symptoms are anxiety, mood swings, difficulty sleeping, persistent tiredness, sensitivity to heat, swivelling of the neck, an irregular or fast heartbeat, twitching and weight loss[xi]. However, the most common cause of hyperthyroidism in the UK is Graves' disease. This is an autoimmune disease that causes the body's immune system to target the thyroid although there is a strong genetic predisposition and is more likely to occur after a large amount of stress or if the person smokes[xii].

Either way, the particular sources of iodine intake are critical to understand in order to ensure dietary sufficiency is achieved, without causing any of the associated health issues that are caused by consuming too much.

Dietary Iodine Sources

The most common iodine sources in the diet are from fish (white fish in particular) and dairy products and, although seaweed is a higher natural iodine source, it is not commonly consumed in the Western diet. Therefore, if these food groups are not commonly consumed or are omitted from diet altogether, as is the case in a vegan diet, it can cause health issues linked to iodine deficiencies. Vegans are at a much higher risk of iodine deficiency for this reason and must rely on a source of iodine from

either seaweed or artificial supplementation[xiii]. In a UK context, the Scientific Advisory Committee on Nutrition (SACN) actually address a study of 39 “healthy” vegans in their most recent iodine review. This study found that the mean iodine level for the group was 20.1µg, which, according to WHO criteria, is indicative of severe iodine deficiency; although they acknowledged the study had a small sample size. However, this is still something to be mindful of with an increasing number of people turning to veganism. Searches for the term ‘veganism’ on popular search engine Google have increased 9-fold over the last 10 years (Figure 2).

Figure 2. Google searches for the term veganism in the last 10 years[xiv].

These trends are likely to have an impact on the prevalence of iodine deficiency. Although an increase would likely have a greater effect on women as a recent survey by the Vegan Society found that 63% of vegans in the UK were women[xv] whereas this figure has been reported to be as high as 79% in America[xvi].

In the UK, a third of the daily iodine intake is derived from dairy produce with a large percentage of that coming from cow’s milk. The iodine content of milk can fluctuate across the UK, influenced by factors such as the type of feed, hygiene levels, and the time of year the milk is collected. For example, iodine is at higher levels in milk during the winter months, which is largely down to the cows being kept inside during this period and being fed supplement enriched silage[xvii]. However, the average iodine content in milk in 2007 was recorded at 30µg/100g[xviii]. Although, it is interesting to note that a study found that organic milk had 42% less iodine than regular milk[xix].

Research in 2019 suggests up to 23% of Britons now use milk alternative which was an increase of 4% from the previous year. Interestingly, 26% of women opted for a plant-based alternative, and which was as high as 33% in women aged 16-24-year old. Sales in oat milk alone rose by as much as 71% in 2017[xx]. With more people turning to dairy free milks derived from nuts or grains, the problem arises where these alternatives often contain little to no iodine. Therefore, if dairy milk is totally replaced in the diet, that could reduce a quarter of the dietary iodine intake. This is a significant amount if that group are already deficient or are borderline.

Seaweed is a staple food in the likes of China, Japan and South Korea and, although seaweed was traditionally incorporated into diets in various forms across the British Isles, particularly in Wales and Ireland, it has become something of forgotten food in the Western world. In contrast, the Korea National Health and Nutrition Examination Survey from 2009 established a database that found the median iodine intake to be 375.4µg per day with seaweed accounting for 65.6% of the total intake[xxi]. Seaweed, of the right source and species, is an ideal way to ensure iodine sufficiency is met because it is a natural source of iodine, with some sources offering organic, sustainable and allergen free seaweeds. Also, due to the natural levels of iodine, only a small amount of seaweed is needed to achieve the RNI, with only 0.5grams of the PureSea® Natural (Hebridean *Ascophyllum nodosum)* seaweed containing as much as 350µg. This means that it is easily incorporated into a recipe and product development formulations and used effectively in a capsule form.

Research demonstrates that humans have consumed seaweed for millennia, as a readily available and nutrient dense source of essential nutrition. Archaeological evidence supports that it was this dietary inclusion that was key in the evolution of the larger and more intelligent modern human brain from early Homo sapiens 2-2.5million years ago. The research concludes that this is likely due to the polyunsaturated fat content and the impacts of antioxidant activities in neuroprotection[xxii], as well as the integral function of iodine in cognitive development and function and affecting memory and mental acuity[xxiii].

Prevalence of Iodine Deficiency

The World Health Organisation (WHO) estimates mental impairment, due to iodine deficiency, affects more than 2 billion people worldwide which is a staggering figure, and which - at the time - was 35% of the entire global population[xxiv].

The most recent National Diet and Nutrition Survey (NDNS) - which is a rolling survey carried out in the UK - found that almost half of the women participating had a urinary iodine level that was less than 100µg/L, which is classified as mildly deficient according

to the World Health Organisation (WHO). Meanwhile, 1 in 6 were below 50µg/L, which would be classed as moderately deficient.

Furthermore, the UK, along with Russia, are the only advanced economies within the top 10 nations with evidence of deficiency that have not introduced universal salt iodisation (USI). However, the UK was generally assumed to be sufficient until a study in 2011 found that the median urinary iodine measurements in 664 participating 14-15 girls was only 80.1µg/L, with 69% of the group being below 100µg/L. The area with the highest prevalence was found in Belfast, Northern Ireland, with deficiency being as high as 85%.

This deficiency spills into pregnancy too, and although the WHO state anything below 100µg/L (as measured in Urinary Iodine Concentration, UIC) is classed as deficient, the requirements for iodine are advised to be higher during gestation. This is reflected in the higher proposed limit of 150µg/L UIC[xxv] before being considered deficient in iodine. This means that there will be a higher percentage of deficiency during pregnancy, which is supported in a recent study from the UK, where out of 1040 mothers tested, 62% were found to deficient. This is alarming in light of the evidence that links iodine levels as being essential for foetal cognitive development, with iodine deficiency causing an observed reduction in IQ. This provides further support on the vital reasons for women to obtain sufficient iodine in the diet.

Pregnancy and the Need for Natural Iodine

With iodine deficiencies during pregnancy recognised as a challenge, addressing this is extremely important, especially as iodine sufficiency during foetal development is critical. The developing foetus requires an iodine source from the mother as during the first 20 days the foetal thyroid gland has not fully formed and therefore the foetus is solely dependent on the mother's supply. In response, the maternal supply of thyroxine is increased up to 50%[xxvi]. Following this period, the foetus needs adequate iodine levels to produce their own hormones as they play a vital role in the process known as organogenesis (essentially the growth of organs) and in the construction of the brain and the central nervous system. Evidence suggests that this hormone action occurs through binding to nuclear receptors which are found in most organs[xxvii]. A study in Norway, found that maternal iodine levels below 100µg/L during pregnancy resulted in lower language skills in children up to 18 months of age. In severe cases, iodine deficiency can lead to cretinism[xxviii]. Meanwhile, iodine deficiency during pregnancy is thought to correlate with disorders such as neonatal mortality, hyperactivity, attention disorders, and a substantial reduction in IQ[xxix].

Following birth, breastfeeding has been demonstrated to be more efficient at delivering sufficient iodine in children when compared to an oral pill[xxx]. Evidence from these studies also suggest that the breastmilk becomes prioritised regarding iodine and could leave the mother seriously deficient without sufficient intake levels to provide for both her and her child. This is supported by a systemic review that predicted that supplementing breast feeding mothers with iodine could save the National Health Service (NHS) up to £199 per mother, with an average increase in IQ of 1.22 points[xxxi]. Meanwhile, another similar systematic review and metanalysis found that iodine deficiency could result in a potential loss of up to 7.4 IQ points[xxxii].

During pregnancy it is also important to choose a natural source of iodine. A study conducted using *Ascophyllum nodosum*, which is the underpinning seaweed species of Seaweed & Co.'s PureSea® range, was found to release iodine in a more sustained way, compared to an artificial source, such as potassium iodine[xxxiii] (Figure 4). This is thought to be due to the iodine being bound within the fibre, meaning a slower release as it is broken down. The research suggests also that when iodine stores were replete, surplus iodine was excreted from the body. Safety is imperative during pregnancy and it is recommended that any seaweed source is tested in independent and accredited laboratories for aspects of safety and nutrition, and that the seaweeds is from organic, clean source free from heavy metals and pollutants. Knowing your source is especially important as iodine levels can fluctuate depending on species and source location.

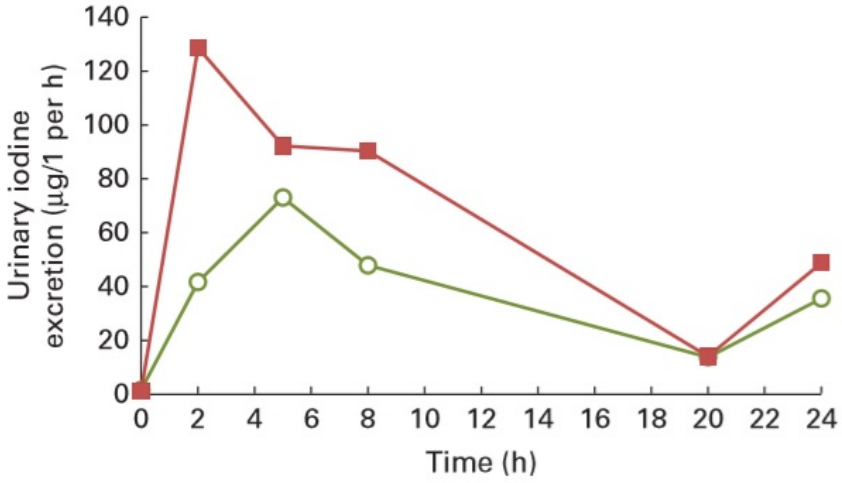

Figure 4. Urinary iodine excretion over 24h after the ingestion of a dose of 712mg of iodine from potassium iodide (■) for PureSea® species Hebridean Ascophyllum nodosum (○).

Hair, Nails and Skin

As key features of women's health and beauty products, hair, skin, and nail health can be seriously impacted through a lack of natural iodine – which as highlighted is far more common in women. Severe and prolonged hypothyroidism and hyperthyroidism can cause hair loss[xxxiv]. Hair growth normally returns following treatment, and it may take several months to experience hair loss or growth due to the nature of the hair's long-life cycle. Hair loss due to a thyroid disorder is often diffuse, meaning patches are lost[xxxv]. The exact mechanism is unknown, but it is believed to be related to the thyroid hormone receptor beta 1 being expressed in the human hair follicle[xxxvi]. The reason for this is believed to be due to a reduction in hair quality opposed to a change within the hair cycle[xxxvii].

Nail health can be impacted by thyroid issues, with one reason for this being that a reduced metabolic rate impacts the amount of sweat produced by the body. Sweat plays a role in maintaining the moisture of the skin and nails and in its absence, can cause them to become dry and brittle[xxxviii]. In more extreme cases, a condition known as onycholysis can occur. This condition causes the nail to become separated from the nail bed[xxxix]. This condition is also often referred to as 'plumber's nails'[xl].

Another common symptom of iodine deficiency is dry, flaky skin[xli]. The skin is regulated by thyroid hormone receptors and this action is widely recognised in scientific literature[xlii]. In one study, dry skin was reported in 63% of people classified with hypothyroidism[xliii]. This has been accredited to a lowered rate of skin cell regeneration as a result of lower thyroid hormone levels[xliv]. Also, as with nails, a reduction in sweat and moisture can cause the skin to become dry and flaky[xlv].

However, ensuring iodine sufficiency can reverse and prevent these conditions from occurring. Products that are found to be naturally abundant in iodine are supported by six EFSA approved health claims. This is the case with the PureSea® range, one of which is that iodine supports the maintenance of healthy skin.

Conclusion

Through all stages of a women's life iodine is integral – from being in the womb, to having their own children, and all the way to old age. Deficiency during foetal development can lead to a reduction in IQ and have an effect on learning, which can have a negative impact on lifelong potential. As an adult, iodine is required to maintain normal thyroid function and ensure an adequate production of the hormones T3 and T4. Deficiency, and an underactive thyroid can cause several symptoms that can have a negative impact on everyday life, through feeling fatigued, being forgetful, inducing

weight gain and depression. In addition, inadequate iodine intake during pregnancy can risk deficiency in both the mother and the child. This can also prevent the foetus from developing properly and potentially causing various negative behavioural conditions, the severity of which being higher in association with the level of deficiency.

Iodine deficiency can also result in poor quality and health of the hair, nails and skin causing them to become brittle, dry, and damaged. Beauty-from-within is a key trend in the market, providing better looking and feeling hair, skin and nails through diet as opposed to topical treatments.

With evidence suggesting almost half of all women in the UK could be deficient, and with peaks above these levels for key demographics such as young girls, vegans, and pregnant women as examples, these symptoms are likely to be quite common. The predominant source of iodine in the UK is from dairy products, and with more people looking to dairy alternatives as well as plant-based diets, then the risk of iodine deficiency is only like to increase.

A solution which easily addresses each of the issues highlighted is through the regular consumption of the right type of seaweed, delivered in ingredient formats for use in any food, beverage and nutrition products.

The PureSea® range of seaweed ingredients are sustainably wild harvested from the pristine Scottish Outer Hebridean islands and is carefully processed using unique technologies ensuring a safe natural source. The PureSea® range can be organic, vegan and Kosher certified, with each batch tested for safety, quality and nutrition – specifically iodine levels.

This ensures the ingredients are suited for use in any application The PureSea® range is delivered in powder and granule formats ensuring ease-of-use and application in almost any food, beverage, or nutrition product to deliver nutrition, health and flavour benefits. The range even includes a flavourless powder, which allows for use in any application without any impact on the wider product.

A reliable, known dose of iodine is imperative, and due to PureSea® seaweed being a good natural and vegan source of essential iodine, it also allows for 6 EFSA approved health claims that iodine supports normal:

- Development in Children
- Cognitive Function
- Healthy Skin
- Energy Yielding Metabolism
- Thyroid Health
- Nervous System

About the Authors

Dr Craig Rose is a marine biologist, founder and managing director of Seaweed & Co. Craig has worked commercially and on research projects on the benefits of seaweed for around 15 years, and leads several research projects with university partners, is on industry advisory bodies and has presented at numerous conferences and to the media.

Michael Taylor is a registered associate nutritionist, with a degree in Food and Human Nutrition. Michael works for Seaweed & Co. and has conducted research on various aspects of nutrient deficiency.

Seaweed & Co. as a company advise on, supply and accredit seaweed, using proprietary technologies and techniques. Their Organic and Kosher certified PureSea® range of seaweed ingredients are supplied into the food, health and nutrition markets. Their seaweeds are sustainably wild harvested, naturally rich in iodine, uniquely DNA Authenticated for world class analytical traceability, and extensively batch tested and accredited for safety and quality.

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