Report of the Scientific Committee of the Spanish Agency for Food Safety and Nutrition (AESAN) for the assessment of the risk associated with the consumption of macroscopic algae with a high iodine content

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Reference number: AESAN-2012-003

Report approved by the Scientific Committee on plenary session on February 22nd, 2012

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Abstract

Iodine is essential for the synthesis of thyroid hormones responsible for the development of the central nervous system, growth, and regulation of the basal metabolic rate. In general, it is required to ensure that the human body is functioning correctly. One of the risk factors associated with eating macroscopic marine algae with a high iodine content is that the excess iodine in the body seems to contribute to an increase in thyroid pathologies. This is suggested in the report by the European Commission's Scientific Committee on Food (SCF), which indicates that ingestion of iodine-rich algae derivatives, especially dried ones, can provide a potentially dangerous iodine intake. In recent years there have been some food alerts for food containing macro-algae with a high iodine content. Since the consumption of macro-algae is on the increase in Spain, the Executive Management of the Spanish Agency for Food Safety and Nutrition (AESAN) has requested that the Scientific Committee draft a report, which, as and when necessary, will be used as the basis to establish management measures that lower the risk associated with macro-algae intake. The nutritional evaluation study of the Spanish diet performed by the Spanish Agency for Food Safety and Nutrition (AESAN, 2012) shows that the iodine intake amongst the adult population in Spain stands between 74 and 102 µg/day. However, there is still a lack of information of the intake of algae amongst the Spanish population. On the contrary, the latest reports by the World Health Organisation (WHO) and the United Nations International Children's Emergency Fund (UNICEF) suggest that the Spanish population displays optimal nutrition of iodine, given that the median urinary iodine excretion is higher that 100 µg/l. We believe that although at present the consumption of this type of algae does not pose a risk to the Spanish population, it could be advisable to adopt a maximum limit for iodine content at 2,000 mg/kg of edible algae dry matter. This amount is the same for all the species. It is also advisable that the population has a moderate consumption,

especially amongst small children and pregnant women. This is to avoid ingesting amounts that exceed maximum recommended values, which could have negative effects on thyroid function (especially important during growth and development stages).

Key words

Macroscopic algae, iodine intake, thyroid disorders.

1. Introduction

Iodine (with chemical symbol "I") is essential for the synthesis of thyroid hormones responsible for the development of the central nervous system, growth, and regulation of the basal metabolic rate. In general, it is required to ensure that the human body functions correctly.

In nature, iodides and iodates are found in soil and rocks. Natural water and ice erosion processes and the subsequent leaching process of the land have meant that many areas of the planet are poor in iodine, the majority of which is found in seawater and the beings that live in the sea.

The presence of iodine in the thyroid gland was discovered in 1895. However, it was not considered as an essential element for human beings until the beginning of the 20th century when Marine and Kimball demonstrated that goitre is caused by an iodine deficiency (Zimmermann, 2008). Since then many studies have been carried out which have shed light on the effects of an inadequate intake in foetuses, children and adults. These tests have also allowed for the establishment of iodine requirements in terms of age, gender and the physiological state of the body. As well as goitre and hypothyroidism, iodine deficiency can cause very serious and irreversible neurological disorders especially in foetuses and children.

Illnesses linked to iodine deficiency have had a high incidence amongst the global population throughout history. In fact, in Ancient Greece, algae or starfish used to be prescribed to cure goitre. For years, the health programmes of a significant number of countries, including Spain, have recommended the consumption of foods rich in KIO_3 or KI as a source of iodine (WHO, 1996). Recent studies in Spain show the importance of controlling iodine levels in pregnant women and have highlighted the inadequate iodine nutrition in certain regions of the country (Foz, 2004) (Sánchez-Vega, 2008).

The incidence of illnesses due to a high intake of iodine has been scarce but this is on the increase in developed countries.

One of the risk factors is the incorporation of high iodine content marine algae in the diet. Its consumption is recommended by experts of the catering sector as "products of high nutritional value." However, incorporating this food into our normal diet could turn out to be harmful to our health, according to the report created by the European Commission's Scientific Committee on Food (SCF). The report highlights that the intake of algae derivates rich in iodine, especially dried products, can provide a potentially dangerous iodine intake (SCF, 2002). In recent years there have been some food alerts for food containing macroalgae with a high iodine content.

Specific regulation for the placing on the market of algae in foods is scarce. France was the first country in the European Union (EU) to set out specific rules on the use of marine algae.

Macroalgae consumption is increasing in Spain. Brown algae, specifically those belonging to the *Laminaria* genus, have high iodine levels, which could have harmful health effects. In addition, the Scientific Panel on Contaminants in the Food Chain (CONTAM) of the European Food Safety Agency (EFSA) has published a report urging that Member States lay down macroalgae consumption criteria in accordance with iodine intake from other sources. Due to these three factors, the Executive Management of the Spanish Agency for Food Safety and Nutrition (AESAN) has requested that the Scientific Committee draft a report, which, as and when necessary, will be used as the basis to establish management measures that lower the risk associated with macroalgae intake.

2. Iodine in food. Toxicity. Recommended intake values

2.1 Iodine content in foods

Iodine content in foods varies. Highest levels are found in food of marine origin (algae, fish and crustaceans).

In industrialised countries the most significant sources of iodine comes in the form of eggs, cereals and dairy products. The concentration of iodine in milk varies depending on the time of year and the amount of iodine added to the animal feed. Another dietary source to bear in mind in Spain is the consumption of iodised salt.

Table 1 shows the iodine content of some of the most frequently consumed foods.

Table 1. Iodine contents (expressed as µg/kg of wet weight) in foods commonly found in our diet

Seafood	Iodine (µg/kg)	Food of animal origin	Iodine (µg/kg)	Food of plant origin	Iodine (µg/kg)	Other food	Iodine (µg/kg)
[1]Fresh algae	1,000 - 2,000	[3]Eggs	388-530	[4]Cereals (average value)	47	[4]Freshwater fish (average value)	30
[1]Fish (average value)	1,220	[2]Semi-skimmed UHT milk	86	[4]Fruits (average value)	18	[1]Drinking water	<15
[1]Seafoods (average value)	798	[2]Skimmed UHT milk	111	[4]Pulses (average value)	30	-	-
[2]Megrim	161	[2]Whole UHT milk	90	[4]Vegetables (average value)	29	-	-
[2]Whiting	270	[2]Natural yoghurt	37	[2]Lentils	15	-	-
[2]Sardine	289	[2]Semi-cured Manchego cheese	341	[2]Rice	22	-	-
[2]Hake	18	[2]Rabbit	18	[2]Chick peas	15	-	-
[2]Cockles (in water)	271	[2]Pork (loin)	26	[2]Spinach	28	-	-
[2]Muscles (marinated)	400	[2]Chicken (drumstick)	69	[2]Fresh green asparagus	20	-	-
[2]Tuna in oil	342	[2]Baby beef (loin)	56	[2]Oranges	21	-	-
-	-	[2]Baby beef (tenderloin)	28	[2]Strawberries	5	-	-
-	-	[2]Beef (loin)	28	[2]Tomatoes	22	-	-
-	-	[2]Beef (tenderloin)	49	[2]Potatoes	41	-	-
-	-	[2]*Chorizo*	109	[2]Mushrooms	157	-	-
-	-	[2]*Salchichón*	147	[2]Onions	89	-	-
-	-	[2]Serrano ham	114	[2]Grapes	3.3	-	-
-	-	[2]Cooked ham	109	[2]Pears	21	-	-
-	-	[2]Lamb (chop)	54	[2]Bananas	24	-	-
-	-	-	-	[2]Kiwis	3.3	-	-

Sources: [1](SCF, 2002) [2](MSC, 1999) [3](EuroFIR, 2011) [4](WHO, 1996).

2.2 Iodine toxicity. Reference Values

Iodine is involved in the synthesis of thyroid hormones T3 (3,5,3`-triiodothyronine) and T4 (3,5,3`,5`-levothyroxine). Both are regulated by the Thyrotropin or the TSH hormone, which in turn is controlled by thyrotropin-releasing hormone or TRH, which acts directly on the anterior pituitary increasing the secretion of TSH.

Hormones T3 and T4 are involved in practically all physiological functions geared towards maintenance of the body in general:

- They have calorigenic and thermoregulating properties.
- They increase oxygen consumption.
- They stimulate synthesis and degradation of proteins.
- They regulate mucoproteins and extracellular water.
- They are involved in the synthesis and degradation of fats.
- They are involved in glycogen synthesis and glucose use.
- They are vital for the development of the central and peripheral nervous systems.
- They are involved in muscle contraction processes and intestinal motility.
- They are necessary for the formation of Vitamin A from carotenes.
- They stimulate growth.
- They are involved in development and tooth eruption.

Iodine levels that are significantly higher or lower than those required for the thyroid to work properly can give rise to metabolic disorders of various degrees of seriousness.

In this respect, Spain and the rest of the EU countries have set out recommended iodine intake values as per person and day (over an average of 15 days) depending on age, gender and special physiological state (pregnant or breast-feeding women).

Table 2 compares the recommended values for some countries in Europe (including Spain), USA, the World Health Organisation (WHO) and the EU (Cuervo et al., 2009). It shows that the largest differences relate to those values established for most at risk populations: children, pregnant women and breast-feeding women.

The SCF has set recommended intake values to be used in labelling through the whole of the EU. These values are brought together in Appendix I of Commission Directive 2008/100/EC, of 28 October 2008, which specifies a value of 150 µg I/day (EU, 2008).

An excessive consumption of iodine is difficult to quantify given that there are populations whose intake is very high yet they apparently display no adverse effects.

High iodine levels block the synthesis of thyroid hormones. This causes hypothyroidism which, during neonatal and breast-feeding periods, can affect the neurological development of the children and even cause permanent loss of cognitive function. It can also cause hyperthyroidism in adults (FSANZ, 2010). In general terms, an excess of iodine in the body seems to contribute to an increase in thyroid pathologies such as Hashimoto's thyroiditis, Graves' disease, toxic nodular goitre and non-toxic diffuse goitre. It can also induce hypothyroidism in autoimmune glands (Miyai et al., 2008) (Patrick, 2008) (Zimmermann, 2009).

Table 2. Iodine (I) intake reference values (per person and day) in differents EU, USA and WHO countries

[1]Spain	I µg	United Kingdom	I µg	Nordic countries	I µg	Germany, Switzerland y Austria	I µg	France	I µg	Belgium	I µg	Ireland	I µg	[2]Europe	I µg	USA	I µg	[3]FAO/ WHO	I µg
Children																			
0-6 months	35	0-3 m	50	-	-	0-4 m	40	-	-	-	-	0-3 m	50	-	-	-	-	-	-
6-12 months	45	4-12 m	60	6-11 m	50	4-12 m	80	-	-	6-12 m	50	4-12 m	60	6-11 m	50	-	-	0-12 m	90
1-3 years old	55	1-3	70	1-2	70	1-4	100	1-3	80	1-3	70	1-3	70	1-3	70	1-8	90	1-6	90
4-5 years old	70	4-6	100	3-5	90	4-7	120	4-6	90	4-6	90	4-6	90	4-6	90	-	-	-	-
6-9 years old	90	7-10	110	6-9	120	7-9	140	7-9	120	7-10	100	7-10	100	7-10	100	-	-	7-12	120
Men																			
10-12 years old	125	11-14	130	>10	150	10-13	180	> 10	150	11-14	120	10-14	120	11-14	120	9-13	120	>12	150
13-15 years old	135	-	-	-	-	-	-	-	-	-	-	-	-	-	-	>14	150	-	-
16-19 years old	145	>15	140	-	-	15-50	200	-	-	>15	130	>15	130	15-17	120	-	-	-	-
> 30 years old	140	-	-	-	-	>51	180	-	-	-	-	-	-	>18	130	-	-	-	-
Women																			
10-19 years old	115	11-14	130	> 10	150	10-13	180	>10	150	11-14	120	10-14	120	11-14	120	9-13	120	>12	150
>20 years old	110	>15	140	-	-	13-51	200	-	-	>15	130	>15	130	15-17	130	>14	150	-	-
		-		-	-	>51	180	-	-	-	-	-		>18	130	-	-	-	-
Pregnant Women	135	-	140	-	175	-	230	-	200	-	130	-	130	-	130	-	220	-	200
Breast-feeding Women	155	-	140	-	200	-	260	-	200	-	160	-	160	-	160	-	290	-	200

Source: (Cuervo et al., 2009) [1](Moreiras et al., 2009) [2](SCF, 1993) [3](FAO/WHO, 2002).

When iodine supplementation reaches 1,500 µg/day, the function of the thyroid in healthy men is significantly inhibited (SCF, 2002).

However, the problems that are caused by excessive iodine intake are more serious in those populations whose normal intake is deficient.

In areas where iodine content is adequate or normally above recommended values, a high percentage of healthy adults are capable of tolerating concentrations above 1,000 µg/day. In such cases, the thyroid is able to adjust itself to a wide intake interval in order to regulate the synthesis and releasing of thyroid hormones. On the other hand, in those who display or have displayed thyroid disorders, increases in the iodine dose at microgram level can cause either hypothyroidism or hyperthyroidism (Zimmermann, 2009). If we compare studies on the effects of high iodine intake between the population of China and Denmark, the results show that in China, where average intake stands at 544 µg I/day, slight increases in autoimmune thyroiditis and subclinical hypothyroidism were detected. In Denmark however, where iodine intake is low, clinical cases of these illnesses (hypothyroidism and hyperthyroidism) increased. These discrepancies are attributed to the differences in previous iodine values. But, environmental variables and genetic susceptibility can also have an effect (Zimmermann, 2009).

Some studies in China suggest that goitre and thyroid disorders can occur in children whose iodine intake falls within the 400-1,300 µg/day interval. This is based on an international study on the high number of cases of children between the ages of 6 and 12 years whose chronic iodine intake of at least 500 µg I/day was linked to an increase in thyroid size. An intake of between 300-400 µg I/day in healthy children seems not to cause any adverse effects (Zimmerman, 2009).

There are studies showing that exposure to high iodine concentrations in pregnant women could be linked to congenital goitre and hypothyroidism in children (Thomas and Collett, 2009).

Based on the available evidence, the SCF concluded that when dietary intake of iodine is 10 times higher than normal, goitre formation is possible. Furthermore, such levels generally cause thyroid pathologies (SCF, 2002). Therefore, this Committee has laid down tolerable upper intake levels (UL) for iodine amongst the European population (Table 3).

Table 3. Tolerable upper intake levels for iodine

Age (years)	Upper intake levels (µg/day)
1-3	200
4-6	250
7-10	300
11-14	450
15-17	500
Adults	600
Pregnant women	600
Breastfeeding women	600

Source: (SCF, 2002).

The UL value for iodine intake established by the Joint FAO/WHO Expert Committee on Food Additives (JECFA) stands at 1,000 µg/day for adults. In the USA, Australia and New Zealand, this is limited to 200 µg/day for children between the ages of 1 and 3 years, 900 µg/day for teenagers and 1,100 µg/day for adults (AFSSA, 2009) (FSANZ, 2011).

In Europe, some population groups exceed established ULs. A study was carried out in France on the dietary intake of iodine. The results showed that children between the ages of 3 and 9 years exceeded their corresponding UL for their age group by 5.9% (AFSSA, 2009).

In general, the most common causes of excess iodine are:

- Consumption of medication containing iodine.
- Consumption of food supplements based on mineral salts or algae.
- Normal consumption of algae in the diet.

3. Iodine levels in macroalgae. The risk associated with their intake

Marina algae, also called macroalgae, are classified into three large groups based on their colour: brown, red and green algae, belonging to the Phaeophyceae, Rhodophyta and Chlorophyta divisions respectively. In general, brown, red and green macroalgae produced as a result of aquiculture in China, Japan, the Philippines and Korea have a high iodine content, especially those belonging to the *Laminaria* genus (FAO/WHO, 2002) (SCF, 2002) (AFSSA, 2009). Brown algae are the largest in size. Such as the case of giant kelp (*Macrocystis pyrifera*, *Ascophyllum nodosum*), which can grow to lengths of 20 m.

They have been used in China, Japan and Korea as a food and condiment for centuries. From there their use has spread to other Asian countries and more recently they reached Western countries forming part of international cuisine (FAO, 2002).

Current global consumption is difficult to quantify. This is because algae products (salted, dried and fresh) are on the market. These include flavourings (for rice, ready-made soups, spaghetti, noodles, etc) and seasoning in a large array of dishes. They are also added in mixes with other vegetables, consumed as a snack, in salads, etc.

At present, algae are considered to be a food with a high nutritional value due to their high vitamin and mineral content (MacArtain et al., 2007). However, the incorporation of certain species of algae into the diet can imply a risk, as is stated in the SCF report. It specifies that "the consumption of iodine-rich algae products, especially in dried products, can be harmful to health" (SCF, 2002).

Iodine content in algae varies greatly and depends on a large number of factors. An analysis of 12 different species of macroalgae taken from supermarkets showed iodine concentrations from 16 to 8,165 µg/g of dry matter. Similar results were found after analysing 35 algae samples from Galicia, Spain. Their iodine content was between 35 µg/g and 7,088 µg/g of dry matter, the latter value corresponding to the *Laminaria ochroleuca* species (Romarís-Hortas et al., 2009).

It was also found that iodine content in a certain species varies greatly depending on a large number of variables (Teas et al., 2004). These factors include the time of year the algae are harvested, the water salinity, storage conditions and processing.

It has been verified that after a drying process at 60 ºC *Laminaria* spp. displayed a reduction of approximately 27% in their iodine content (AFSSA, 2009). Similarly, food preparation and cooking processes decrease iodine content by 20% when food is fried, 23% when roasted and 58% when boiled (SCF, 2002) (Teas et al., 2004).

Furthermore, iodine bioavailability decreases when it is ingested along with foods containing substances that impede the absorption or incorporation of iodine in the body. This is the case for glucosinolates, for example. Such foods include those vegetable species belonging to the *Cruciferae* family like cauliflower, Brussels sprouts, red cabbage, etc. (Camean and Repetto, 2006). An *in vitro* bioavailability study on six species of brown, red and green macroalgae taken from Galicia showed values of 17% for *Laminaria ochroleuca/Laminaria saccharina,* 16% for *Gelidium sesquipedale,* 10% for *Palmaria palmata* and less than 5% for the rest of those species tested (*Porfiria* spp., *Undaria pinnatifida*, *Sargassum* spp., *Spirulina platensis*, etc.) (Romarís-Hortas et al., 2011).

Table 4 brings together the different iodine contents of edible macroalgae species. The species with the highest concentrations belonged to the *Laminaria* genus (between 574 and 11,580 µg/g of dry matter) and *Gracilaria verrucosa*, which has slightly lower values (8,483 µg/g of dry matter).

Normal algae consumption in the diets of Asian countries brings about a greater tolerance to a high iodine intake. Studies performed in Korea and Japan showed average iodine levels of 479 and 544 µg I/day respectively, 66% of which came from algae consumption. The population of Korea displayed intakes of up to 4,086 µg I/day yet did not experience a higher incidence of thyroid disorders than that of other countries (Kim et al., 1998).

However, iodine concentrations in species of the *Laminaria* genus are so high that when consumed, even in areas traditionally rich in iodine, they are linked to the presence of endemic goitre. This is the case on the island of Hokkaidō in Japan, where the *kombu* is common in the diet. Furthermore, various cases of dietary hypothyroidism have been seen in newborn infants whose mothers consumed high levels of algae, such as the case of the child with stunted growth due to the mother's daily intake of *kombu* as a snack (Miyai et al., 2008).

According to the SCF, in places that have an endemic iodine deficiency, the consumption of foods or condiments produced using macroalgae that contain more that 20 mg/kg of dry matter could lead to an excessively dangerous intake. However, this is not the case for those countries where iodine intake is appropriate to high (SCF, 2002).

In 2009, Food Standards Australia New Zealand (FSANZ) withdrew soya milk from the market. It had been imported from Japan and fortified with macroalgae extracts whose consumption was linked to 38 cases of thyroid disorders. When the milk consumed by said patients was analysed, it revealed abnormally high iodine contents due to the presence of *kombu* (*Laminaria* spp.) (FSANZ, 2010).

In March 2010, FSANZ coordinated another national food alert for the presence on the market of a preparation of dried algae belonging to the *Sargassum fusiforme* species. After the alert, an infant was hospitalised with hypothyroidism probably due to the consumption of this product by the mother.

Table 4. Iodine content (µg/g dry matter) in edible algae

Scientific name		Common name	Source									
			(Dawczynski et al., 2007)	*(Teas et al., 2004)	*(Martinelango et al., 2006)	(AFSSA, 2002)	(Jimenez- Escrig and Goñi, 1999)	(Miyai et al., 2008)	(Romaris-Hortas et al., 2011)	(ISC, 2011)	(Burtin, 2003)	(MacArtain et al., 2007) mg/100 g wet weitgh*
Brown algae	*Laminaria spp.*	*Kombu*	1,700 to 11,580	746 to 8,165	-	2,000 to 10,000	4,400	2,300	-	-	1,500 to 8,000	-
	Laminaria saccharina	*Kombu dulce*	-	-	574	-	-	-	3,703 to 7,088	2,366	-	-
	Laminaria digitata	*Kombu*	-	-	1,997 to 3,134	-	-	-	-	2,479	-	70 (3,500)
	Hijikia fusiforme	*Hijiki*	262	391 to 629	-	-	420	-	-	-	-	-
	Fucus vesiculosis	-	-	-	276	108 to 276	-	-	-	-	-	-
	Undaria pinnatifida	*Wakame*	-	66 to 1,571	-	-	170	-	63 to 326	150-550	-	3.9 (195)
	Himanthalia elongata	*Sea spaghetti*	-	-	-	-	-	-	63 to 266	20-40	-	10.7 (535)
Red algae	*Palmaria palmata*	*Dulse*	-	44 to 72	39 to 72	-	-	-	77 a 128	150-550	-	10.2 (510)
	Porphyra spp.	*Nori*	550	16 to 43	-	-	20	-	35-102	-	-	1.3 (65)
	Gracilaria verrucosa	-	-	-	-	8,483	-	-	-	-	-	-
Green algae	*Ulva lactuca*	Sea lettuce	-	-	25	-	-	-	66-137	240	-	1.6 (80)
	Enteromorpha intestinalis	*Green stringy weed*	-	-	-	-	-	-	-	70	-	97.9 (4,895)

*(MacArtain et al., 2007). Value in parentheses is µg/g dry matter, assuming an average humidity of 80%.

Due to events, Australia's Health Department recommended that health professionals revise those unexplained cases of thyroid disorders, and warned the health authorities and the population on the consumption of products containing macroalgae. As a result of all this, the FSANZ is carrying out market studies in order to limit iodine content in these foods.

Under the Rapid Alert System for Food and Feed (RASFF) of the European Union, over the last three years more than a dozen food alerts have been issued due to high iodine content in dried algae or their derivatives (RASFF, 2011).

Currently, the placing on the market of algae in foods is hardly subject to specific regulations.

France was the first country in the European Union to set out specific regulations on the use of marina algae for human consumption as a non-traditional food. Twelve macroalgae (six brown, five red and two green) [sic] and two microalgae have been authorised as vegetables and condiments in France with a maximum iodine content of 6,000 µg/g of dry matter for two species of *Laminaria* (*Laminaria digitata* and *Laminaria saccharina*) and a maximum of 5,000 µg/g of dry matter for the remaining species. Subsequent opinion has suggested the need to reduce these levels further.

Consequently, in 2002 the French Food Safety Agency (AFFSA) (now called the National Food Safety Agency-ANSES) recommended to keep the maximum iodine level at 6,000 mg/kg of dry matter for the two *Laminaria* species, keeping the following conditions of use on labelling: It should only be consumed as a condiment and in a maximum quantity of 30 mg/day of dry matter for adults and 15 mg/day for children under the age of 4 years. The *Gracilaria verrucosa* species also has high iodine concentrations (up to 8,483 mg/kg of dry matter). It was recommended that its labelling should contain the same consumption recommendations as for *Laminaria*. For the rest of the algae it was recommended to reduce iodine concentration to 2,000 mg/kg of dry matter (AFSSA, 2002).

Subsequently, more detailed studies on iodine intake amongst the French population have shown that consumption of algae with 6,000 mg/kg is a health risk. It has thus been recommended that a maximum of 2,000 mg/kg of dry matter is established for all edible algae species (AFSSA, 2009).

In 2006, CONTAM was required to issue its opinion on the risks that marine algae consumption has on the health. Given the large difference in iodine intake values amongst the population of Europe, CONTAM concluded that possible algae consumption recommendations should be made on a national or even regional level (EFSA, 2006).

In Spain the quantity of fresh algae has gone from 25-30 tonnes in 2003 to 140 tonnes in 2005. Galicia and Cantabria in the north are the regions where this industry is gaining most in importance (Oshima, 2006). Production reached 63 tonnes in Galicia in 2009 (Conselleria do Mar, 2010).

In Spain, there are no data available on algae consumption. With regard to the habitual intake of iodine, available data were obtained through the National Survey of Spanish Dietary Intake (ENIDE) (AESAN, 2011). Data show values of 68 to 125 µg/day in men and 62 to 117 µg/day in women. The average therefore stands at 97 µg/day and 90 µg/day respectively. In relation to iodine intake in the Spanish population, in 2009 the work group on Iodine Deficiency Disorders (IDD) of the Spanish Society of Endochrinology and Nutrition (SEEN) stated in the Huelva Declaration (Vila, 2010) that "the latest reports from the WHO and UNICEF indicate that the population of Spain has optimum iodine nutrition". The latest studies carried out in Asturias, Valencia, Alicante, Catalonia, the Basque Country,

Galicia and Almeria, and the thyrobus project involving the cities of Madrid, Malaga, Barcelona and La Coruña, show in all cases that median urinary iodine concentrations exceed 100 µg/l. This implies a very relevant change given that the WHO considers that a population has an optimum iodine nutrition when the median iodine urinary concentration stands between 100 and 199 µg/l. Undoubtedly, the increase in people who consume iodised salt has been the most important determining factor influencing such a change. However, a recent study carried out by members of the IDD group, which analysed iodine content in "368 samples of milk from 47 commercial brands taken from 8 Spanish cities", highlighted that milk could have contributed to this new situation since an average iodine concentration of nearly 250 µg/l was found. Such a finding is probably due to practices in farming but can also be attributed to European legislation, which requires that animal feed is supplemented with a minimum amount of iodine. There is no information as to health problems associated with the excess consumption of iodine.

Data provided by ENIDE show that iodide intake values amongst the adult Spanish population (between 18 and 64 years) are between 74 and 102 µg/day, with a median habitual intake in woman of between 87.9 µg/day and 92 µg/day, depending on age, and 97 µg/day in men. Using the Recommended Dietary Allowances (RDA) for the adult Spanish population of 140 µg/day in men and 110 µg/day in women (Moreiras et al., 2009), women consume 77.1% and men consume 71.4% of their RDA (AESAN, 2012). In France, according to the results of a study, the median consumption in adults is 109 and 89 µg/day in men and women respectively. This means that RDA percentages stand between 72% and 59%, whereas a lower intake was found in people over the age of 60 years (around 53% of their RDAs). In another study, recorded intake was higher and stood at around 150 µg/day in adults and 130 µg/day in children. These data show that there is a slight iodine deficiency risk amongst the populations of both Spain and France (AFSSA, 2009).

However, there are still no algae intake data for the Spanish population. The ENIDE survey only includes 28 entries out of more than 23,000 corresponding to algae intake. This constitutes just 0.12% of the total. These entries denote three terms: algae, *kombu* algae, *nori* algae and *wakame* algae mainly eaten as such or in dishes such as mushroom burgers. From the data available, the ENIDE survey with 3,800 participants and a total of 323,000 ingredients taken over 24 hours and a recorded estimated intake of three days, algae consumption in Spain is not significant (own data). The French Agency also records low algae consumption in France with approximately five lines out of a total of 500,000 consumption lines (AFSSA, 2009).

Given the similarities in algae consumption between the populations of Spain and France (with very little entries in consumption surveys), and the fact that iodine consumption amongst the adult population is just as similar, it is possible to apply the ANSES report (AFSSA, 2009) in the case of Spain. The report recommends a maximum intake of dry algae with a high iodine content (especially the *Laminaria* genus) as food or condiment of 30 mg/day and a maximum dry algae content of 2,000 mg/kg. Bearing in mind both this intake and the iodine intake for the Spanish adult population, the formula for algae consumption would be:

30 mg/day x 2,000 mg/kg = 60 µg/day (RDA for the Spanish population between 140 and 145 µg/day in men and between 110 and 115 µg/day in women).

If we bear in mind that the median habitual daily intake of iodine amongst the Spanish population stands at 87 µg/day in women and 97 µg/day in men (ENIDE, unpublished data), and considering that the Tolerable Upper Intake Level (UL) in adults is 600 µg/day (and higher for ULs in the USA and for the WHO/FAO/IAEA) (WHO, 1996), consumption of such iodine quantities from dry algae is of no concern. By taking into account the data from other European countries, SCF believes it highly unlikely to be able to exceed the tolerable upper intake level of iodine in adults (SCF, 2002).

Conclusions of the Scientific Committee

Overall, the data available so far, about iodine intake due to the consumption of algae in the Spanish population do not seem to indicate that there may be, in the short term, hazard of iodine intake above the maximum levels, at less in adults, since we do not have data in children.

In any case, we must point out that the habitual consumption of algae with a high content of iodine (especially those belonging to *Laminaria* genus) can provide significant amounts of iodine and this could imply, mainly in young children, the overcoming in some cases of the iodine tolerable upper intake level established in the European Union.

As a final conclusion and although at this time the consumption of this type of algae is not important in the Spanish population, it would be recommendable to adopt a maximum limit for iodine content at 2,000 mg/kg of edible algae dry matter, regardless of species and to advise a moderate consumption of those algae that have a high iodine content in the adult population and occasional in young children and pregnant women in order to avoid risks of high intakes that could have negative effects over the thyroid function, with special repercussion in growth and development stages.

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