IODINE
IN FOOD SYSTEMS
AND HEALTH

BOOK OF
ABSTRACTS
This document contains abstracts of a selection of the presentations given during the first international conference organized by the World Iodine Association: Iodine in Food Systems and Health, held in Italy, Pisa in 2017. These abstracts are made available on-line with kind permission of the speakers.

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VP and Senior Industry Specialist at Arthur D. Little, BE  
Iodine – an element for all seasons.

- Iodine is one of the most versatile elements reflecting the number of functionalities associated with its atomic structure including a heavy nucleus and a large electronic orbital system.
- This versatility is reflected in the number of applications of substantial industrial and practical significance of iodine.
- These range from X-ray contrast agents – essential in the diagnosis of various pathologies – and nutrition for humans and animals to pollution control where iodine allows to abate mercury emissions out of coal fired power plants or water and stain repellent coatings for textiles and paper.
- While finding widespread applications – iodine is characterized by a narrow supply structure – two countries – Chile and Japan – accounting for close to 90% of the world output.
In 1811, Barnard Courtois of France found that violet vapor with a strong smell was generated while producing niter from seaweed ashes, and that when the vapor was cooled down, it turned into purplish-black flake-like crystalline material having a metallic luster. This was the beginning of iodine chemistry. Today about 90% of iodine in the world is produced from niter in Chile (60%) and from natural gas brine in Japan (30%). Iodine use is closely linked to our daily lives. In this paper the history of iodine production and the industrial applications of iodine today will be reviewed.

Production of Iodine

In Japan, the major iodine production occurs in the southern Kanto gas field which extends over Chiba, Tokyo, and Kanagawa prefectures along the east-central coast of the main Japanese island of Honshu. The brine in this gas field contains approximately 50~150 mg/L of iodine. Iodine is produced from the brine, which is pumped up from the wells (depth: 500~2,000m) associated with methane gas, by a blowing-out process or an ion-exchange resin process.

Industrial Applications of Iodine

[Pharmaceuticals] The first major area of iodine consumption is in pharmaceuticals, primarily as X-ray contrast agent, which are injected intravenously or intracerebrally to produce X-ray photographs of the internal structure of the body. Nonionic contrast agents, iohexol and iopamidol, are the most common agents. [Disinfectant] Iodine is an effective germicide for a wide range of microorganisms. Polyvinyl pyrrolidinone-iodine complex, Betadine, is extensively used because of its germicidal, bactericidal, fungicidal, and general disinfecting properties. [Polarizer] Polarizing plates are indispensable materials for liquid crystal displays (LCDs) such as LCD TV, cell phone, and automotive navigation system. In the widely-used dyed PVA polarizing plates, iodine-dyed PVA films are the most effective polarizers. [Agrochemicals] Today a number of halogen-modified compounds are found among the best-selling agrochemicals. However iodine-containing compounds are in the minority. Modern iodine-containing agrochemicals are as follows: Iodsulfuron-methy-sodium (Herbicide), Proquinazid (Fungicide), and Flubendiamide (Insecticide). [Novel Applications] Iodine is playing an important role in the development of novel solar cells such as dye sensitized solar cells (polyiodide electrolyte) and Perovskite solar cells (light absorber). Solar cells are the promising novel applications of iodine.

References
Dr. Vincenzo Costigliola MD  
President of the European Medical Association (EMA), BE  
Iodine is health: the role of the medical community in preventing IDD.

Created in 1990 by doctors from 12 Member States, the European Medical Association (EMA) is an independent non-profit organization, which offers every European doctor the opportunity to add a European dimension to their professional and social life and to actively influence the development of an European healthcare.

According to the WHO, Iodine deficiency is the world’s most prevalent, yet easily preventable, cause of brain damage. All degrees of iodine deficiency, in pregnant women and neonates, affect mental development. Overall, the number of countries where iodine deficiency is a public health problem has halved over the past. However, not enough progresses have been made in order to curb this condition. Partially, this is due to the fact that the international community fails at recognizing that IDD is still a serious public health problem.

In Europe, there are at least ten countries that are considered mildly iodine deficient – among which: Italy, France, Denmark and Ireland – therefore it is surprising that EU policy-makers are not concerned with the risks associated with IDD nor they believe these should be placed among the priorities of the political agenda.

EMA believes that the role of doctors is decisive, as they have the duty to educate their patients as well as to notify the European and national competent authorities about the risks of IDD. However, doctors cannot work alone. Patients organizations, civil society organizations and representatives of the entire agri-food supply-chain must cooperate in order to prevent IDD in Europe and abroad.
Mr. Rutger Schilpzand  
Executive Secretary of the Choices International Foundation, NL  

The role and responsibility of the food industry in tackling IDD.

Choices International is a global initiative to improve healthier consumer food choices, driven by science based criteria. Key actions are the use of a positive front-of-pack healthy choice logo, reformulation and food communication. The organization is based on a unique and fruitful cooperation between frontrunners in the food industry and independent leading food and nutrition scientists to contribute to the prevention of non-communicable diseases.

All around the world a fundamental nutrition transition takes place. Global food policy has to make shift from quantity to quality. Due to huge accomplishments in the global food chain, there are in principle enough calories for everybody. But tremendous issues remain regarding food quality, that lead to malnutrition, obesity and food related non-communicable diseases. The food supply and consumer food choice urgently need fundamental changes.

Three levers of change, that are already present, should be used way more seriously, jointly and in coordination:

1. Basic food education by means of the national food pyramid;
2. Criteria to identify the products lowest in fat, sugar and salt in each food category;
3. Fortification.

Consequences for a suitable micronutrient supply are:

1. Largest part of micronutrient intake should be provided by basic foods;
2. Healthy food criteria’ lead to a preference for nutrient dense food products in each food group;
3. Targeted fortification in pockets of micronutrient deficiencies. Next to a balanced salt iodization, there should be a preference for fortified products that comply with these criteria.

Joint action is a key requirement to make these three levers effective, also when it comes to Iodine Deficiency Disorders prevention. A multi-stakeholder approach is necessary to put this in practice. Choices International has developed an effective strategy to align the health agendas of national health authorities, international food industry, NGOs and academia and to facilitate joint implementation. The key level of such implementation is the national scale, supported by regional collaboration. The EU is well positioned to take a leading role in this issue.
Mr. Wouter Lox  
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Harmonized Salt Iodization instead of Universal Salt Iodization: a better approach to become a reality in Europe?

The joint WHO and UNICEF report published in 2007 on “Iodine deficiency in Europe: A continuing public health problem” identified the situation of Iodine Deficiency in Europe as a major public health concern. Even though the health consequences of iodine deficiency for adults, infants and children are well known - including irreversible mental retardation - yet the European policy makers are not motivated to act. Instead, they are raising the concerns of the impact of iodine deficiency on public health at the same level as the sugar, fat and salt reduction campaigns.

We believe that iodine deficiency should come back on the national agenda of European governments. The fact that the European Commission DG Health & Food Safety is not recognizing Europe as being iodine deficient exacerbates this situation.

A possible European approach could be to promote Harmonized Salt Iodization (HSI). Complementing food grade salt with a fortified salt that would provide the minimal level of the recommended iodine content, and which can be freely marketed in Europe, would help to raise awareness, facilitate the marketing of products with iodized salt and help to eliminate the iodine deficiency prevalence in Europe.

The upcoming WIA Conference in Pisa on 15th-17th November 2017 should initiate and result in a common multi-stakeholder commitment of all stakeholders involved. The commitment should include a common strategy to help eliminate iodine deficiency in Europe. The public pledge to undertake this commitment should be the benchmark for the European policy-makers to include the assuring of optimum iodine nutrition as a strategic public health goal in their strategic planning in 2020-2024. It should trigger a concerted action and the creation of a multi-stakeholder platform that is measuring the implementation and improvement of the iodine nutrition in Europe.
Iodine supplementation of livestock feeds: animal requirements and potential for food fortification.

The efficiency of livestock production continues to improve in all species, associated with developments in animal nutrition and management. However, many trace elements, including iodine, have not received the recent attention of research into livestock requirements and as such supplementation is often based on a balance of old data and current experience.

Iodine is an essential trace element for thyroid function. It is incorporated into the thyroid hormones thyroxine (T4) and triiodothyronine (T3). These hormones have multiple functions as regulators of cell activity (energy metabolism) and growth, transmitter of nervous stimuli and as an important factor for brain development.

Livestock rations require supplementation with iodine in order to account for the shortage of natural iodine in feedstuffs and satisfy the nutritional requirements of all livestock classes. For example, iodine deficiency in poultry and swine is seldom seen because normally all of their daily ration is feed fully fortified with iodine. Conversely, deficiencies are seen in ruminants because 50 to 100% of the daily ration is forage, which is typically low in iodine. Clearly, careful attention to rationing for mineral balance is important on ruminant farms.

Feed biofortification is an opportunity to improve animal welfare but also for human nutrition. However, the fortification of eggs and milk for the human population is significantly limited in the EU by the feed additive legislation which restricts the feeding of iodine to laying hens and ruminants for milk production. For example, in the UK the current levels of dietary supplementation of iodine in practice are already near to the recommended maximum content in the complete feed and therefore cannot be markedly increased to have any appreciable impact on the iodine content of eggs and milk.

Therefore, FEFAC recognizes the need to bring IDD to the attention of EU policy-makers implementing a multi-stakeholder approach which considers the different routes, two of which are feed and food biofortification, that should be followed to tackle IDD.
Ms. Laura Linda Henderson  
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The global strategy of patients’ organizations to tackle IDD

Patients’ Organizations (PO) from many countries all over the world joined the TFI (Thyroid Federation International) to work for the benefit of those affected by thyroid disorders. The TFI first convened in Toronto at the 11th International Thyroid Congress in September 1995. Starting from a base of six member organizations, the Federation has grown to include approximately 20 thyroid organizations in many parts of the world, including Europe, North America, Australia and Japan.

Patients’ Organizations play an important role in tackling Iodine Deficiency Disorders as it is the primary cause of thyroid and cognitive disorders. TFI’s role is essential in promoting awareness and the understanding of thyroid disorders. TFI has stimulated and coordinated awareness campaigns all over the world, e.g. International Thyroid Awareness Weeks (ITAW) during the past few years. All affiliated POs have organized diverse kinds of promotional campaigns in their countries through social media, television talk shows, press releases, magazines, public and educational meetings. For example, in Italy, thanks to PO awareness campaigns, iodized salt use in the population increased from 30% in 2006 to 60% in 2016.

The following stakeholders play important roles in recognizing iodine deficiency and therefore decreasing iodine deficiency:

- Patient Organizations by promoting awareness campaigns;
- Researchers and physicians by educating patients and following iodine health related issues;
- Farmers/Dairy Industries by adding the correct amount of iodine in their products;
- Food/Salt Industries by adding the correct amount of iodine in their products;
- Health Departments by promoting laws and overseeing the iodine intake by the general population, including children and pregnant women.

The Thyroid Federation International, together with its POs, aim to reach the World Health Organization’s goal, i.e. 90% of the worldwide population use iodized salt to decrease thyroid disorders.
Iodine (I) is an important micronutrient for human and animal health. It plays a vital role in thyroid hormone synthesis and function. Iodine deficiency causes health complications collectively known as iodine deficiency disorders (IDD). The WHO recommend a daily intake of 150 µg iodine for an adult. The literature suggests that about 70% of children (age 6-12) in Gilgit-Baltistan (Pakistan) have varying levels (severe to mild) of I deficiency.

The hypothesis underpinning this study is that I status of the population of Gilgit-Baltistan is mainly controlled by geochemical factors. The overall aim of this study is to assess the factors controlling I in soils and water of Gilgit-Baltistan, the availability of I to plants and ultimately to the local population. Soil, water and plant samples were collected from districts within Gilgit-Baltistan. Plant and soil samples were in extracted 10% TMAH prior to analysis for total I concentration by ICP-MS. Soil organic carbon and pH were also determined.

The soil samples were alkaline, with pH values from 8.01 to 9.03, and had low organic carbon contents (0.12% to 0.59%). Total soil I concentrations ranged from 272 – 1079 µg kg\(^{-1}\) compared to a worldwide mean of 2600 µg kg\(^{-1}\). Iodine concentration in water samples ranged up to 10.2 µg L\(^{-1}\). Iodine concentration in wheat (8.24 - 35.8 µg kg\(^{-1}\)) and other plants was very low reflecting low soil and water I concentration. Considering the average individual daily wheat consumption in the region (~350 g) provides 75% of the calorie intake, it is likely that the population of Gilgit-Baltistan does not receive sufficient I from their diet in the absence of supplementation.

Future plans for this study include analysis of iodised salt used by some people in the area and also assay of human biomarkers for I in the local population. From these data we can assess the efficacy of iodised salt supplementation and whether further measures, such as biofortification of the staple crop (wheat), may be required.
Content: Iodine is a trace element required for the production of thyroid hormones, essential for metabolism, growth and brain development, particularly in the first trimester of pregnancy. Milk and lean fish are the main dietary sources of iodine in the Norwegian diet and fish has the highest naturally occurring content of iodine. Few studies have examined the iodine concentration in these food groups during the last decade, and updated information is important since insufficient iodine intake is an issue affecting considerable proportions of the European population. Thus, the aim of the present study was to provide updated analyzed values of iodine concentration in Atlantic cod (Gadus morhua), saithe (Pollachius virens), haddock (Melanogrammus aeglefinus), pollack (Pollachius pollachius), wild and farmed Atlantic halibut (Hippoglossus hippoglossus), and canned tuna.

The iodine content was determined using inductive coupled plasma-mass spectrophotometry (ICP-MS). The iodine concentration in the fish species varied between 7.8 µg/100 g (farmed Atlantic halibut, n=40) and 1210 µg/100 g (pollack harvested in fjords in western Norway, n=18). There was large variation between individuals within the same species, and between fish of the same species from different geographical areas. For cod (n= 121) the overall mean iodine content was 190 ± 160 µg/100 g compared to 119 µg/100 g reported in the Norwegian Food Composition Table. For pollack (n=41), the overall mean iodine content was 550 ± 430 µg/100 g compared to 143 µg/100 g reported in the Norwegian Food Composition Table. The large variation between individual fish within the same species is a challenge when used for calculating nutritional intake. In the Norwegian Food Composition Table, only mean values are given, thus, no statistics could be performed comparing mean values on new and old values. In conclusion, large variation in iodine content was detected between species and within species. Information about standard deviation and range would highlight this variation if reported in food composition data bases.
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Regional and seasonal variation in milk iodine concentrations throughout the UK.

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Milk and dairy products are a major source of dietary iodine for many individuals within the UK due to their frequent and often daily consumption. However, iodine content of milk may be variable depending on geographical region, seasonality, soil or feed iodine concentrations and subsequent milk processing.

This study aimed to identify seasonal and regional variation of iodine concentrations (μg/L) in unpasteurised milk sampled from farms located in five geographical regions throughout the UK. Milk samples were provided by the National Milk Laboratories (NML). Samples were collected during both the summer (n=104) and winter (n=111) months from dairy farms in Cornwall, Cumbria, Durham, The Midlands, Norfolk and Sussex. Elemental analysis of iodine in the milk samples was assessed by ICP-MS.

Despite large variation of soil iodine concentrations throughout the UK, no significant difference in iodine content of milk samples was observed in milk samples collected from farms within the five geographical regions (P<0.05). This lack of geographical variation was observed during both the summer and winter months. Large variation in milk iodine concentrations was observed between herds within similar geographical regions (from ~40 μg/L to 1600 μg/L). Following pairwise analysis, seasonal differences were observed between winter and summer milk samples. Overall, winter milk samples had significantly greater iodine concentrations compared to summer samples from the same farm (n=104, P<0.001).

This study clearly demonstrates inter herd variation of iodine content in milk samples. However, this variation cannot be attributed to geographical location of the farms despite a broad range of soil iodine concentrations observed. This would imply that variation is dependent upon either additional dietary intake or the use of iodine containing sterilisation processes.
Dietary determinants of iodine status in pregnant women from three European mother-child cohorts.  

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Introduction: Iodine is required for the synthesis of thyroid hormones. Thyroid hormones are essential for neurodevelopment, especially in periods of rapid growth such as during fetal development. Maternal iodine deficiency in pregnancy has been associated with adverse cognitive outcomes in the offspring. Identifying the food sources of iodine in pregnancy is key to ensuring adequate iodine status in pregnant women. Populations differ in the consumption patterns of iodine-rich foods (e.g. milk and fish) but also the iodine content of foods is highly variable between countries (e.g. as a result of the iodine content of soil, and farming practice). We hypothesised that there will be some similarity, but also differences in the main dietary iodine sources in European pregnant women.

Method: Three mother-child cohort studies were used: INMA (Spain) n=1460, Generation R (The Netherlands) n=1580, and ALSPAC (UK) n=1849. Iodine status was assessed using urinary iodine-to-creatinine ratio (µg/g) measured in a spot urine sample that was collected at ≤18 gestational weeks in INMA and Generation R, and ≤13 gestational weeks in ALSPAC. Dietary intake of individual foods and food groups was estimated from a food frequency questionnaire (FFQ) administered during pregnancy. Data were analysed using multiple linear regression adjusted for energy intake and confounders.

Results: The consumption of dairy products was positively associated with iodine status of pregnant women in all three cohorts with similar effect size per 100g increase in consumption (INMA, β=1.035, p=0.001; Generation R, β =1.022, p=0.004; ALSPAC, β =1.013, p<0.0001). Fish and shellfish, and eggs were positively associated with iodine status in all three cohorts, however the associations were only statistically significant in INMA for fish intake (β=1.139, p=0.024), and in Generation R for egg intake (β=1.741, p<0.0001). Some food groups, such as meat and meat products in INMA (β=0.850, p=0.003), fruit, nuts and seeds in ALSPAC (β=1.010, p=0.011), and cereal and cereal products in Generation R (β=1.136, p<0.0001) were significant cohort-specific predictors.

Conclusion: Well-known sources of iodine, such as dairy, eggs and fish were significantly associated with iodine status in pregnant women in all three cohorts. However, differences were also observed, with some food groups, such as cereals, identified as cohort-specific predictors. These differences could be as a result of differences in food choice but also of the variability in iodine concentration of foods. This study suggests that public health interventions focusing on improving dietary iodine intake of pregnant women should be tailored to country-specific food groups.
Challenges and limitations of urine iodine measurements in the evaluation of IDD programs.

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Programs initiated to prevent iodine-deficiency disorders (IDD) may not remain effective due to changes in government policies, commercial factors and human behaviour, which all may affect the efficacy of IDD prevention programs in unpredictable directions. Urinary iodine concentrations (UIC) are commonly measured in population samples to monitor IDD prevention.

The methodology of UIC analysis is challenging. Many laboratories performing UIC measurements participate in the Ensuring the Quality of Iodine Procedures (EQUIP) program of the U.S. Centers for Disease Control and Prevention. Unfortunately, only a small number of samples are analyzed and there is a common lack of transparency of comparative findings for the participating laboratories. The EU-funded EUthyroid consortium has established elaborated recommendations on how to collect urinary samples and to avoid pre-analytical and analytical pitfalls. In addition, partners are offered to send 75 samples to the central EUthyroid laboratory at THL Helsinki, Finland. Results of the comparative measurements are then used to recalculate external UIC levels to the EUthyroid standard. First series identified differences between the standard and external laboratories of up to 50% in the UIC value distribution.

Notwithstanding the challenges in the methodology of UIC analyses, it is important to keep in mind that UIC measurements only serve to steer IDD prevention programs. To assess the effectiveness of IDD prevention, however, no study of iodine consumption can replace the direct measurement of health outcomes and the evaluation of the benefits, costs and cost-effectiveness of the programs.
Clinical studies in Portugal have demonstrated the existence of a generalized deficiency in iodine of pregnant women and with school-age children [1 - 3]. A general lack of awareness within the Portuguese population about the importance of iodine in the diet has also been identified [4, 5]. Thus, in this work we report the program underway in country to monitor the real content of iodine in school meals.

Collection of foods from schools was designed to represent school meal program in place. Foods were organized into three groups. One hundred and forty four samples cooked with iodization salt (soup and main course) were collected from primary schools across Lisbon District (Group I). Twelve samples were used as reference of real iodine content from a pilot school (Group II). One hundred and forty four samples composed according consumption data were used as reference of minimum iodine value (Group III). A total of three hundred samples were analysed in pooled or single corresponding to thirty six laboratory samples and analysed in triplicate. The iodine contents were determined by inductively coupled plasma-mass spectrometry (ICP-MS) after alkaline extraction with TMAH (tetramethylammonium hydroxide) in a graphite block system during 3 hours at 90 °C, under the frame of ISO/EN 17025:2005 and EN 15111:2007.

The concentration of iodine in analysed samples showed a wide range of levels varying according to the group. Group I from 9.9 µg/100g in chicken to 23.2 µg/100g in fish. Group II the highest value (32.3 µg/100g) was found in soup. The lowest value (below limit of quantification) was found in meat of Group III. The ratio between Group I and Group III was used to estimate effectiveness of the program, and the biggest difference was found in fish and narrowest was determine in chicken. The distance between iodine content in Group I and Group II was used to monitoring bias due to pooled samples. The major difference was observed in turkey. Sodium content is discussed as a contribution to clarify the iodine differences. Cooking procedure, iodization salt absorption, and operator performance were identified as main factors contributing to the differences between real and prescribed content.

Iodization salt content determined in foods as consumed is an appropriate approach to evaluate fortification program and risks of both inadequate and excess iodine intake.

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Suboptimal iodine status among pregnant and lactating women in Norway.

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Inadequate iodine intake during pregnancy and lactation may negatively influence the developing brain of the infant. We assessed iodine status among pregnant and lactating women in Norway by evaluating urinary iodine concentration (UIC), breast milk iodine concentration (BMIC) and iodine intake from food and supplements. During 2016, 804 pregnant women and 175 lactating women (18-44 years) from the Oslo area were included. Spot urine samples were collected from all women, and the lactating women provided four breastmilk samples, which were pooled.

After an alkaline pre-treatment, the samples were analyzed for iodine concentrations using ICPMS-QQQ. Data on 24 hours iodine intake and habitual iodine intake, in addition to iodine intake from supplements, were collected. The median (p25, p75 percentiles) UIC was 92 (59, 140) µg/L and 64 (39, 95) µg/L in pregnant and lactating women, respectively. The median (p25, p75 percentiles) BMIC was 68 (45, 98) µg/L. Seventy-five percent and 54% of the pregnant and lactating women had a total intake below the estimated average requirement, respectively. Habitual iodine supplement use was reported by 30% and 19% had taken an iodine-containing supplement in the last 24 hour.

Milk/dairy was the main dietary iodine source (57%), followed by seafood (15%). In pregnant women, smoking and gestational age were negatively associated with UIC and hypothyroidism, while maternal age, and iodine from supplements were positively associated with UIC, explaining 11% of the variance. In lactating women, use of iodine-containing supplements and UIC were positively associated with BMIC, while infant’s age and smoking was negatively associated with BMIC, explaining 33% of the variance. The majority of pregnant and lactating women had suboptimal iodine concentration in urine and breast milk and inadequate intake of iodine from food and supplements. Findings from this study claim for further attention on iodine nutrition during lactation in Norway.
Both iodine deficiency and excess have adverse health consequences. Severe iodine deficiency leads to the iodine deficiency diseases of goitre, cretinism and endemic retardation, but less severe iodine deficiency can impair fertility, brain and motor development and increase embryonal and postnatal death. By contrast, chronic exposure to excess iodine intake induces autoimmune thyroiditis, partly because highly-iodinated thyroglobulin is more immunogenic. Recent introduction of universal salt iodization can have a similar, though transient, effect.

Other nutritional factors are also crucial to thyroid function, most notably selenium and iron with vitamin D having potential relevance. The thyroid is susceptible to a number of autoimmune conditions the most common of which is Hashimoto’s Thyroiditis (HT), a hypothyroid condition characterised by the presence of antibodies to thyroid peroxidase (TPO), the enzyme responsible for the production of thyroid hormones. It is currently accepted that genetic susceptibility, environmental factors and immune disorders contribute to its development.

Iron: Iron deficiency impairs thyroid metabolism. TPO is a haem (iron-containing) enzyme; it becomes active at the apical surface of thyrocytes only after binding haem. Patients with Hashimoto’s Thyroiditis (HT) are frequently iron-deficient since autoimmune gastritis, which impairs iron absorption, is a common co-morbidity. Treatment of anaemic women with impaired thyroid function with iron improves thyroid-hormone concentrations while thyroxine and iron together are more effective in improving iron status.

Selenium: Selenoproteins are essential to thyroid action. In particular, the glutathione peroxidases protect the thyroid by removing excessive hydrogen peroxide produced for thyroglobulin iodination. Genetic data implicate the anti-inflammatory selenoprotein S in the risk of HT. There is evidence from observational studies and randomized controlled trials that selenium/selenoproteins can reduce TPO-antibody titres, hypothyroidism and postpartum thyroiditis. Furthermore, selenium treatment in a randomised, placebo-controlled trial reduced the symptoms of mild Graves’ orbitopathy, a hyperthyroid autoimmune thyroid condition.

Vitamin D: Lower vitamin D status has been found in HT patients than in controls and inverse relationships of serum vitamin D with TPO/thyroglobulin antibodies have been reported. However, other data and the lack of trial evidence suggest that low vitamin-D status is more likely the result of autoimmune disease processes that include vitamin D-receptor dysfunction.

Conclusions: Clinicians should check patients’ iron- and vitamin-D status to correct any deficiency. Adequate selenium intake is vital in areas of iodine deficiency/excess and in regions of low selenium intake a supplement of 50 to 100 μg/day selenium may be appropriate.

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Last year the Norwegian Nutrition Council delivered a report to the Directorate of Health about the iodine nutrition situation in the Norwegian population. The aim of the report was to describe current knowledge about the population's iodine intake and to identify risk groups with too low or high iodine intake. Further, to suggest relevant actions to secure adequate iodine intake in the population. The main method for the exposure assessment was to estimate iodine intake in dietary surveys performed in different age groups during 1997-2013. Data from urinary iodine concentration (UIC) was also compiled.

Dietary sources of iodine in Norway are limited to milk and dairy products, seafood and eggs. Iodized salt contributes insignificantly as the maximum level of iodine added to salt is 5 µg/g. Additionally, the food industry is not permitted to use iodized salt.

Estimated intake of iodine based on dietary surveys showed that the average iodine intake among men in general was sufficient (160-180 µg/day), whereas a larger proportion of the women, and especially the youngest women (18-29 years), had an insufficient intake (average 104 µg/day). Average iodine intake in all women was 110 µg/day. The intake of milk and fish varies considerably and may explain the large variation in iodine intakes. Data from the Norwegian Mother and Child Cohort Study, including more than 60,000 pregnant women showed that 54% had an iodine intake below the Nordic recommendation of 175 µg/day. The UIC from several small studies conducted in 1999-2012 supported the findings from the dietary surveys. The iodine intake of children (2-, 4- and 9 years) was mostly in line with the recommendations of 70-120 µg/day, while 2-year old children with high intake of milk were at risk of excessive iodine intakes. Among adolescents (13 year), the average iodine intake was approximately 100 µg/day (150 µg/day is recommended). The report suggests different actions within seven main areas: 1) universal salt iodization, 2) regulation of iodine concentration in the milk, 3) supplements to women of childbearing age, pregnant women, and breastfeeding women with a low intake of milk, and to people who exclude milk or fish from their diet 4) iodization of other foods, 5) quantify recommended intake of milk in the national dietary recommendations 6) monitoring of food and the population and 7) information to industry, health professionals and the population.

In summary, insufficient iodine intake in groups such as young women, pregnant and lactating women, and individuals with no or low intake of milk gives rise for concern. The report concludes that there is an urgent need for national policies and strategies to secure the iodine status in Norway.
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Agronomic biofortification of crops to address inadequate iodine intake in Ethiopia.

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According to the latest national micronutrient survey, half of Ethiopia’s school age children (48%) and women of reproductive age (52%) have inadequate iodine intake (EPHI 2016), with a prevalence of goiter of over one third in children (35%) and women (35.8%) (Gebretsadikan and Troen, 2016). The impact of iodine deficiency is staggering and has led to determined efforts to address micronutrient malnutrition. The Ethiopian government mandated that all salt be iodized (2011), and although iodized salt was found to reach 85% of households, quality control was a significant issue and 50% of households received inadequately iodized salt, with amounts being substantially higher in rural areas (EPHI, 2016).

The reach of agro-chemicals in the country has been progressing steadily, and has had rapid penetration into rural areas, potentially serving as a useful vehicle for micronutrient-containing fertilizers reaching rural households. The use of zinc-containing fertilizers as a foliar spray on crops has shown that grain zinc content can be substantially increased. This study undertook the assessment of foliar application of iodine on increasing grain iodine content and, potentially, the iodine intake of communities consuming these agronomically biofortified crops. Foliar iodine treatments were carried out on farmers’ fields in Tigray region, in combination with zinc trials, on three major crops – wheat, barley and teff. A minimum of 10 farms per crop were treated. For each farm and crop, grain samples were taken from treated and control plots and are currently being analyzed for iodine content. Results will show the feasibility of this approach as an additional measure for addressing the problem of inadequate iodine intake in rural households in Ethiopia.

References


Iodine uptake, translocation and storage mechanism in spinach (*Spinacia oleracea*).

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Dietary supplementation with iodised salt is the most widely employed prophylaxis for reducing iodine deficiency disorders (IDD); however, given the epidemic level of IDD additional and readily applicable iodine delivery strategies have been proposed, mostly notable biofortification. Previous studies reported that crops have the ability to accumulate iodine following its application to the soil, however, soil properties significantly influence the speciation and availability of iodine to plants. Foliar fortification is a sustainable and productive crop management technique which is beneficial when (1) soil conditions limit nutrient availability, (2) soils exhibit a high rate of loss of the applied nutrient, and (3) when plant physiological factors impair the delivery of nutrients to the desired plant organs. Despite the uncertainty regarding transport pathways, foliar fortification appears to be an effective method of increasing iodine concentration in plants.

In this study we assessed the uptake pathways, translocation and storage mechanisms of iodine in spinach which has previously been recommended for phytofortification programmes aimed at improving human trace element consumption. Plants were grown in an inert substrate to investigate the uptake and transfer of I− and IO3− through the xylem and its storage in mature plants, when applied to the roots. In addition, apoplastic and symplastic solutions were extracted from root tips grown in the presence and absence of a metabolic inhibitor to assess active and passive uptake mechanisms using isotope labelling techniques. Carbonyl cyanide m-chlorophenyl hydrazine (CCCP) was used as a metabolic inhibitor which acts as an ionophore, reducing the functionality of the energy storage molecule, adenosine triphosphate (ATP) and thereby inhibiting the plant’s ability to actively uptake ions. Finally, specific phloem translocation mechanisms of I− and IO3− were identified in young plants over a short-term period using foliar application. Phloem transport mechanisms highlighted by foliar applications show that iodine is suitable for foliar fortification programmes.

The results from this work show that spinach has the ability to accumulate iodine in the edible parts of spinach with no significant difference in uptake between iodide and iodate. Initial results also suggest evidence of a transporter mediated component and a passive uptake mechanism controlled by diffusion to the above ground biomass concentrations.