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SADRŽAJ:

A grain of salt – a cross-sectional study on the consumption of foods containing iodine and sodium among adults from Croatia

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Abstract

Salt is the main dietary source of two important nutrients: iodine and sodium. Deficiency and excess of both minerals results in a number of adverse health effects. However, social media is full of misinformation regarding iodine's role in thyroid diseases. The aim of this cross-sectional study was to determine the types of salt consumed and the consumption of foods naturally containing iodine in adults (19 to 69 years old), both genders, in charge of food shopping and/or meal preparation (N=220), in regard to their health status. Only women reported being diagnosed with Hashimoto's thyroiditis (14.1 %) and having infertility issues (16.8 %). Sea salt is the most commonly used (62.7 %), followed by table salt (45.5 %) and Himalaya salt (29.5 %), with many using two or more types of salt simultaneously. Women diagnosed with thyroid disease were most likely to use only Himalaya salt. Foods naturally containing iodine cannot provide sufficient iodine due to low consumption; milk and dairy are consumed once a day, cheese 4 times a week, eggs 1.9 times a week, and saltwater fish 1.2 times a week. Seaweed, as the natural source with the highest content of iodine, is consumed by 5.9 % of the study participants (one has Hashimoto's thyroiditis). Participants reported high consumption of salt-containing seasonings, and pre-packed, ready-to-eat meals, which contribute significantly to daily sodium intake. Consumption of foods naturally containing iodine is low, but some types of salt could significantly alter iodine's consumption. More studies are needed to determine the exact dietary iodine consumption, especially in vulnerable populations.

Key words: iodine, sodium, thyroid diseases, dietary sources, salt.

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Introduction

Iodine is a trace element important for the synthesis of thyroid hormones, but its importance extends far beyond. Iodine plays a key role in the overall metabolism, growth of the body, and neurodevelopment of foetal brain (Nazeri et al., 2021). Iodine deficiency and iodine excess can increase person's risk for thyroid diseases. The actual risk for thyroid diseases is individually altered, by age, gender, genetic predisposition, environmental factors, personal history of thyroid diseases, concurring diseases, and some medications (Prete et al., 2015).

Sea salt is a general term for salt produced by evaporation of saltwater (sea, ocean or lake). It is less processed than table salt and retains trace minerals which add flavour and colour, but the amount of sodium is comparable to table salt. Yet, the amount of iodine present in sea salt is not considered as sufficient (Medeiros-Neto and Rubio, 2016). Iodized salt is the main source of iodine in diet, given that seafood, dairy and grains from iodine-rich soils contain variable, often low iodine content (Krela-Kaźmierczak et al., 2021). Today, 88 % of the global population uses iodized salt (Zimmermann and Andersson, 2021), yet about 30 % of the world's population is considered at risk of iodine deficiency (Hatch-McChesney and Lieberman, 2022). At the same time, thyroid diseases are on the rise (Taylor et al., 2018); global prevalence of Hashimoto's thyroiditis is 7.5 % in the upper-middle income countries and 11.5 % in the low-middle-income countries (Hu et al., 2022), and the burden is especially high in women. Therefore, it is not surprising that women are especially interested in sharing their opinion and/or experience with dietary iodine and thyroid diseases.

Today, social media is the primary source of information regarding food and health for as many as 85 % of population, especially for younger (Samayyia et al., 2019; Vogels et al., 2022). Some studies report that between 51 % (Borges do Nascimento et al., 2022) up to striking 87 % (Suarez-Lledo and Alvarez-Galvez, 2021) of posts on social media fall in the health misinformation group, and diet-related misinformation is around 36 % (Suarez-Lledo and Alvarez-Galvez, 2021). A large share of iodine-thyroid related information shared online is unproven and can have severe health consequences. Often, women diagnosed with hypothyroidism promote restriction of iodine consumption through foods (especially emphasizing that iodized salt is problematic), and some even promote taking extremely high doses of iodine via supplements (e.g. example of some blogs https://isandra. weebly.com/jod).

Himalaya salt, which is mined from deposits located in Pakistan, due to its pinkish colour, is often marketed as a healthier alternative to table salt. However, despite the content of sodium in Himalaya salt is lower than in table salt, in order for trace minerals present in Himalaya salt to achieve any health benefit, a person would need to consume extremely high amount of salt. Health risks related to excessive sodium consumption surpass this negligible benefit from trace minerals in Himalaya salt (Fayet-Moore et al., 2020). In addition, a recent study found a number of impurities in unrefined samples of salt used for cooking, including Himalaya salt (Ercoşkun, 2022).

Excessive salt, i.e. sodium consumption increases blood pressure (Mente et al., 2014), and various public health strategies have been developed to promote salt reduction to reduce the risk of hypertension, the so called silent killer (World Heart Federation, 2023). Based on reports from Italy, on paediatric (Iacone et al., 2021a) and adult (Iacone et al., 2021b) populations, salt contributed to daily iodine consumption with around 20 % and the adequate intake of iodine (EFSA, 2019) was achieved only in study participants in the highest quintile of salt consumption. It is important to note that World Health Organization conducted an comprehensive meta-analysis on the efficacy and safety of iodized salt on various health conditions, and no overall effect of iodized salt on hypothyroidism was found (Aburto et al., 2014).

We aimed to determine the types of salt consumed and consumption frequency of some foods naturally containing iodine by the general population of adults in charge of food purchase/preparation, in relation to their health status.

Subjects and methods

This is a baseline study for a larger research project regarding iodine's role in health and reproduction. We obtained institutional review board approval from the Ethical Committee of the University Hospital Centre Osijek (decision from October 6, 2021, number of approval R1/13151/2021).

This part of the research was an observational, cross-sectional study conducted on general population from Croatia, both genders, ≥ 18 old. The study-specific questionnaire was anonymous, and participants were asked to complete it only once. Recruitment was done through social media posts, by sharing the link to access the questionnaire, which was prepared in an online form (by using open source Google Forms). The recruitment was done between May and June 2021. From 275 responses, three were excluded due to incomplete reporting.

Questionnaire

The questionnaire consisted of three parts, and primarily consisted of closed-types questions (except for questions about age and residence).

The first part included questions about general and socio-economic characteristics, e.g. age, gender, residence, health issues their food-related household responsibilities.

In the second part of the questionnaire, we asked about types of salt used. Also, with yes/no options participants were asked about their consumption of various bouillons, bouillon cubes, seaweed, soy sauce, and/or pre-packed seasonings for main dishes.

The last part of the questionnaire examined participants' consumption of animal foods that naturally contain iodine within the last month. Additionally, the consumption of pre-packed, ready-to-eat products was also examined. For each food consumption frequency was given, ranging from every day, up to 3 times a week, once a week, once a month, up to 5 times a month and rarely/never.

Statistical analysis

Statistical analysis was performed by software Statistica (v. 14.0, StarSoft Inc., USA), with the level of significance p=0.05. Normality of the data distribution was tested by the nonparametric Kolmogorov-Smirnov test for the comparison of medians and arithmetic mean, and histograms plotting. Categorical data are presented as absolute and relative frequencies, while for numerical data median and interquartile range is used. For the comparison of categorical data within and between groups Fischer's exact test was used. Differences between three independent groups were tested with Kruskal-Wallis ANOVA test.

Results and discussion

Mean age of study participants was 36.4 ± 9.3 years, from 19 to 69 years, 20.2 % males, 77.2 % living in urban area, 11.8 % in suburban area, and 11.0 % in rural area. According to their food-related household responsibilities, 61.8 % said that they are in charge of both shopping and preparing meals, 9.6 % are either responsible for food shopping or meal preparation, while 19.1 % said they only enjoy the meals prepared. Participants who said they are only consuming foods prepared were excluded from the following analysis, so the final number taken in the analysis was 220. Among them, 55.9 % said they have no health issues, 14.1 % have Hashimoto's thyroiditis, 16.8 % infertility issues, 3.6 % have hypertension, diabetes, or dyslipidaemia, and the remaining 9.6 % have other conditions like asthma, chronic pain, and gastritis. To analyse the differences between heath conditions, due to a small number of other conditions, healthy participants were compared to those with Hashimoto's thyroiditis and/or infertility issues. Importantly, all participants who said they were diagnosed with Hashimoto's thyroiditis or infertility issues were women.

The majority of study participants use sea salt (62.7 %), 45.5 % use table salt, 29.5 % use Himalaya salt, and 5.5 % other types of salts (Figure 1), primarily flower of salt. The majority of participants use two (sea and table salt) or more types of salt simultaneously. Other types of salts used were Sicilian, black and smoked salt, declared to be used by one participant each. Himalaya salt is the sole type of salt used by 6.4 % of the study participants, and they were more likely to be diagnosed with Hashimoto's thyroiditis ($p<0.001$).

Table salt is typically mined from underground deposits, and the one available on Croatia's market is usually fortified with iodine. In Croatia, the first regulation of iodine content in salt was introduced in 1953. The initial amount of 10 mg KI/kg was increased to 25 mg KI/kg in 1996, after epidemiological studies have found that goitre was still present in 35 % of the school-aged population of children (Jukić et al., 2008).

Excess iodine intake, though rare, may come from use of high-dose supplements or overeating certain seaweeds. Besides children, infants and the elderly, people with existing thyroid diseases are particularly vulnerable to iodine toxicity and iodine-induced hypothyroidism and hyperthyroidism

(Murai et al., 2021; Farebrother et al., 2019). In our study, only one participant diagnosed with Hashimoto's thyroiditis uses seaweed. Since we did not question participants about their supplement use, we cannot assess the potential risk arising for excessive intake of iodine due to supplementation.

Thyroid diseases are commonly associated with altered blood pressure (Marcisz et al., 2001). Therefore, restrictions in sodium intake for people with thyroid diseases is recommended. Besides the obvious, large amounts of sodium (i.e. salt) can be found in various seasonings and prepacked, ready-to-eat meals (Korošec and Pravst, 2014).

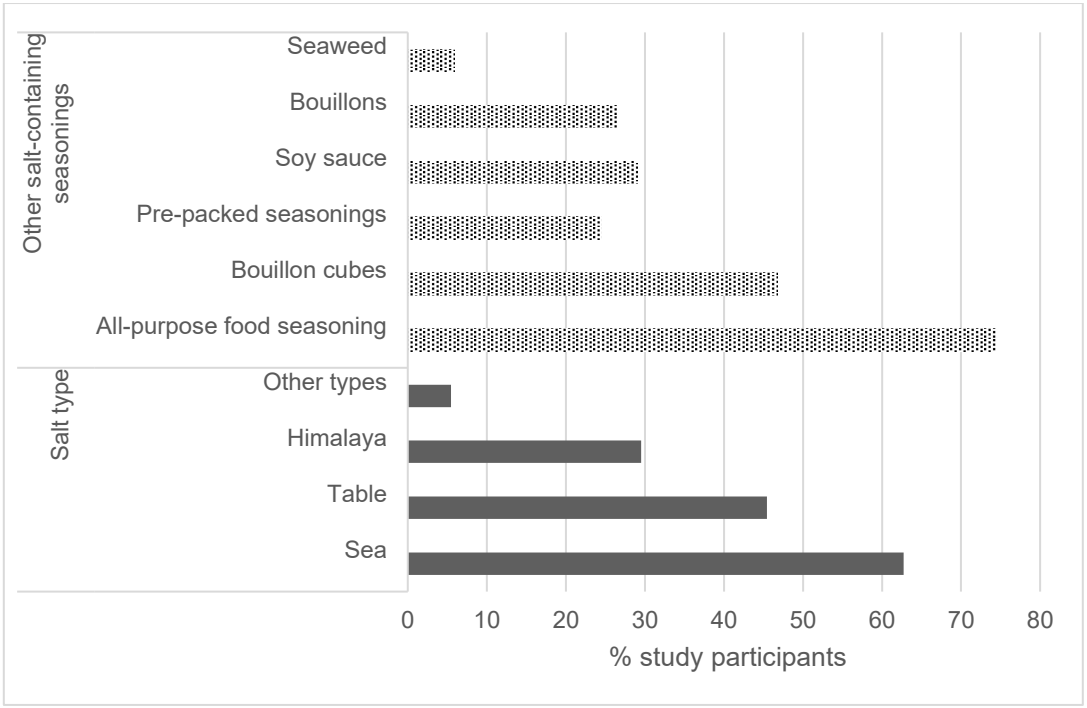

Figure 1. *Consumption of various types of salts and other salt-containing seasonings among study participants (N=220)*

We found that additional sodium is consumed through (Figure 1) all-purpose food seasoning for salty dishes (74.5 %), bouillon cubes (46.8 %), soy sauce (29.1 %), bouillons (26.4 %), pre-packed seasonings for various salty dishes (24.5 %), and seaweed (5.9 %). 6.4 % of the study participants said they use any of the aforementioned products. Additionally, the consumption of pre-packed, ready-to-eat products (Table 1) is another significant contributor to the total dietary sodium intake.

Since iodine is found in soil and water, its content will vary in foods depending on the climate conditions, farming, cultivation, etc. Therefore, all natural dietary sources, like saltwater fish, eggs, milk and dairy will have variable iodine content (Krela-Kaźmierczak et al., 2021).

We found that the consumption of foods naturally containing iodine cannot satisfy the needs for iodine (Table 1). Cheese is consumed 4 times a week, milk and dairy once a day, eggs 1.9 times a week, saltwater fish 1.2 times a week, and shellfish once a month. While participants with no health issues

consume more eggs and cheese in comparison to those with Hashimoto's thyroiditis or infertility issues, no statistical significance was found for the consumption of observed foods (Figure 2).

Table 1. *Consumption frequency of foods naturally containing iodine and pre-packed, ready-to-eat products per person (N=220)*

	Median (25 % - 75 %)	**Corresponding consumption**	**Iodine content* (µg/100 g of product)**
Saltwater fish	0.17 (0.06 - 0.34)	1.2 times a week	7.7 – 110
Shellfish	0.03 (0.00 - 0.17)	once a month	3.81 – 440.18**
Eggs	0.27 (0.14 - 0.43)	1.9 times a week	9.5 – 57.6
Cheese, all types	0.57 (0.28 - 0.86)	4 times a week	7.7 – 30
Milk and dairy	1.0 (0.17 - 1.0)	once a day	19.5 – 21
Pre-packed, ready-to-eat products	0.23 (0.06 - 0.51)	1.6 times a week	

*values retrieved from Krela-Kaźmierczak et al., 2021 except **from Sprague et al., 2021

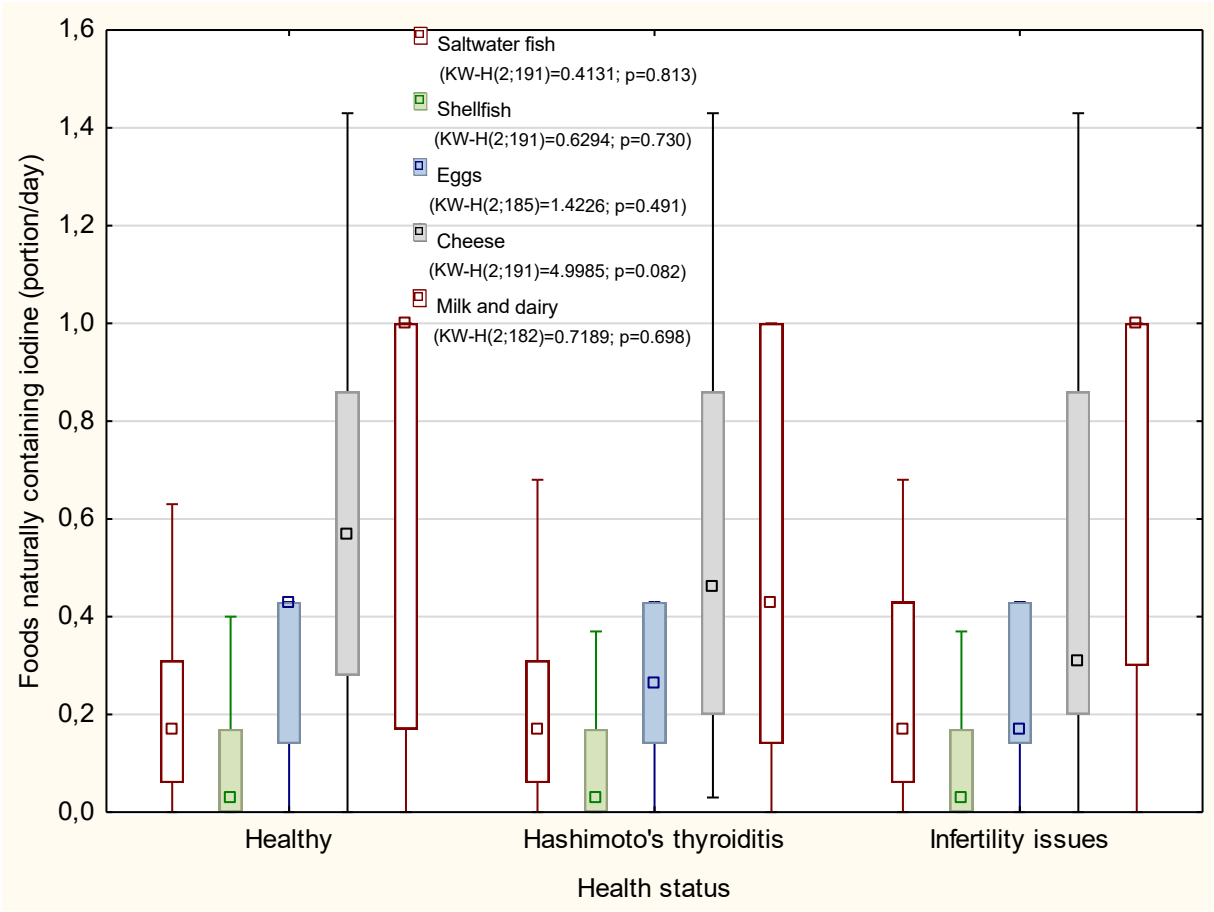

Figure 2. Consumption frequency of foods naturally containing iodine per day between healthy participants (n=123) and those with Hashimoto's thyroiditis (n=31) and infertility issues (n=37) Median; Box shows interquartile range; Whisker shows non-outlier range

KW-H – Kruskal-Wallis ANOVA test

To the best of our knowledge, there are no available results on dietary iodine consumption in adults or other population groups from Croatia. Based on the study conducted on 24 pregnant women from Eastern Croatia (Milos, 2023), their dietary consumption of iodine was 2.8 and 2.3 times higher than the recommended intake, depending on the recommendation considered. The highest contribution to daily iodine consumption, besides salt was from dried meat products, hake, white bread and yogurt. All pregnant women used sea salt (58 %) and/or table salt (50 %) (Milos, 2023). Study conducted on 71 people with thyroid diseases from Primorje-Gorski Kotar County found that they are more aware on dietary sources of iodine (Karuza, 2022). The study found that they limit dairy consumption and eat less of salty foods, and besides salt (sea salt is preferred type of salt used) major iodine sources are meat and meat products (consumed 1.2 and 1.3 times a week) and saltwater fish (2-3 times a week) (Karuza, 2022).

Study limitations and future directions

The results of this small study provide starting point for larger studies, which would focus on dietary iodine consumption, and its status (observed primarily through urinary iodine concentration) in various population groups. The need for dietary consumption of iodine was emphasized in the last national project which analysed effects of salt fortification with iodine on goitre and thyroid diseases in high-risk population groups (Kusić et al., 2012).

Despite small number of participants, the results show that people are using other types of salts (Himalaya salt, black and smoked salt) with unknown iodine content. This provides rationale to conduct a thorough monitoring of iodine content in salts available on the Croatian market and compare its content with national regulations, which is the next stage of our research.

In this study, we focused on foods naturally containing high amount of iodine like saltwater fish and shellfish. In some products, like milk and dairy, iodine content depends not only on season and feeding method, but also on sanitation practices used in the industry (Roseland et al., 2020).

For industry products containing high amounts of salt like meat or bakery products, it should be noted that salt fortified with iodine is avoided since it can alter organoleptic of the final product (Lušnic Polak et al., 2018). However, information about the type of salt used by particular industry is not disclosed so these products should be analysed to determine their iodine content. Also, these products, particularly dried meat and bakery products are consumed in large amount and could potentially contribute significantly to daily iodine consumption, which is the case for sodium.

Additionally, cooking methods can lower iodine's content in foods between 6.6 % to 51.1 % (Rana and Raghuvanshi, 2013), which is especially important to consider for foods not eaten raw, like beans, some leafy vegetables or cereals. Foods of plant origin have lower iodine content in comparison to animal foods (Krajcovicová-Kudlácková et al., 2003), resulting in higher prevalence of iodine deficiency among vegans and vegetarians (Eveleigh et al., 2020). These foods are the so called

goitrogenic foods that can negatively affect iodine's absorption and utilization in the body (Bajaj et al., 2016).

Having in mind the primary aim of this research, the design did not include dietary assessment method which would enable assessment of iodine consumption from beans, cereals and some vegetables, which can be considered as a downside. However, one must remember that salt fortification with iodine was introduced because various population groups were unable to meet iodine requirement through foods naturally containing iodine.

There is an urgent need to analyse the exact dietary iodine consumption, and educate public about harms of low and high iodine consumption on health. Urgency is emphasized by the numerous social media posts often spreading misinformation about iodine, and more interest towards foods from other countries/regions (seaweed, Himalaya salt, etc.), especially among younger generations, with unknown iodine content.

Conclusions

The consumption of foods naturally containing iodine cannot ensure sufficient amounts of iodine, unless combined with iodized salt. The majority of study participants use sea salt and/or iodized table salt but for 6.4 % of the study participants who only use Himalaya salt the risk of insufficient iodine intake should be assessed. Additionally, study participants consume a lot of salt-containing seasonings and pre-packed, ready-to-eat products, which may lead to an excessive sodium intake. Caution is needed, not only for people with hypertension or for other cardiovascular issues, but also for 14.1 % of those diagnosed with hypothyroidism since hypertension often goes hand in hand with thyroid diseases. Given the increased interest towards new types of salts, future studies should consider iodine monitoring in salts available on the market. In addition, more studies are needed to determine the exact daily iodine consumption (through all foods) and iodine's body status in various population groups. These findings can then be used for targeted actions towards public on iodine's role in health.

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