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Original Paper

Assessment of the iodine content of salt consumed in the town of Bechar

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Abstract

Introduction: Evaluating the iodine content in household salt is crucial for public health, particularly in regions
where legislation mandates iodization. In Bechar, Algeria, thirty years after the government established regulations for salt iodization at 30-50 ppm, it is essential to assess compliance and effectiveness. This study aims to evaluate the iodine content in salt consumed by households in Bechar and its alignment with national standards.

Methods: A cross-sectional survey was conducted involving 509 households in Bechar. Schoolchildren were randomly selected from a comprehensive list and asked to provide a 50g sample of salt consumed by their families. The iodine content of these samples was then measured and analyzed against national recommendations.

Results: The median iodine content in the salt samples was 17.50 mg/kg, below the recommended 30-50 ppm. Over 80% of households used either inadequately or excessively iodized salt. Specifically, 73.67% of the samples had iodine levels below 30 ppm, while 7.07% exceeded 50 ppm. Only 19.25% of the samples met the recommended standards. The most commonly consumed salt brands in this study are private label brands. The majority of the samples analyzed show iodine levels below 30 ppm, which is below the recommended level.

Conclusion: This study reveals a significant shortfall in the adequate iodization of household salt in Bechar compared to Algerian standards. Identifying and addressing the causes of this deficiency is critical to ensuring consumer protection and improving public health outcomes.

Keywords: Iodine content- salt iodization-household survey- public health- nutritional standard.

Introduction

Micronutrient deficiency is a silent global epidemic that affects morbidity, mortality, and quality of life, as it hinders socioeconomic development, particularly in low- and middle-income countries (Tulchinsky 2010). Among these micronutrients, iodine is an essential trace element for synthesizing thyroid hormones, which play a crucial role in many tissues' growth, differentiation, and maturation processes, especially bone tissue and the central nervous system (Hetzel and Maberly 1986). Insufficient intake of this trace element can lead to severe conditions known as "iodine deficiency disorders" (IDD) (WHO 2007), including goiter, cretinism, spontaneous abortion, perinatal mortality, and heart failure (Li and Eastman 2012).

The international strategy adopted to eliminate IDD is salt iodization using potassium iodide or potassium iodate enrichment (Tulchinsky 2010). Until 1990, only a few countries like Switzerland, some Scandinavian countries, Australia, the United States, and Canada were fully iodine sufficient. Since then, globally, the number of households using iodized salt has increased from less than 20% to over 70%, significantly reducing iodine deficiency (Pearce et al. 2013). This effort was accomplished by a coalition of

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international organizations, including ICCIDD (later called IGN), WHO, and UNICEF, working closely with national IDD control committees and the salt industry. This partnership was established after the 1990 World Summit for Children.

In Africa, significant progress has been made. In West and Central Africa, 72% of households now consume adequately iodized salt (UNICEF 2008). In Algeria, the January 1990 decree made it mandatory nationwide to use iodized salt at a rate of 30 to 50 ppm for consumption (JORA 1990). It repealed the 1967 decree that set too low standards, between 10 and 15 ppm, and only required the sale of iodized salt in risk areas (Benmiloud 1993). Since then, significant progress has been recorded concerning changes in thyroid anomaly frequencies and household coverage with adequately iodized salt.

However, despite prophylactic programs, deficiencies remain, and the coverage of populations exposed to deficiencies often remains incomplete (Delange 1994). The iodine content in salt must be regularly monitored at various stages (production, commerce, and households) of the distribution system (Adou et al., 2002). After the salt iodization campaign in Algeria, some surveys were conducted to determine the iodine content of the salt consumed.

Unfortunately, no work has been done in the Bechar region (southwest Algeria). Thus, this work represents a first attempt to determine the iodine content of salt consumed in the city of Bechar.

Materials and methods

Study design and sampling

This is a cross-sectional descriptive study to evaluate the iodine content of salt consumed in households in Bechar. The population involved in the collection of table salt used in this work consists of families of 509 students enrolled in various primary schools in Bechar, randomly selected from an exhaustive list of all students enrolled in the city. The students brought 10 to 20 grams of table salt consumed by their families to determine its iodine concentration. For each sample they provided, the students also noted the salt brand. The samples were coded and stored at room temperature, protected from light and moisture until analysis.

Iodine assay in salt

The iodine content in salt was determined using the iodometric titration method (WHO 1994). The assays were performed in triplicate. The titration, based on the reaction mechanism, occurs in two steps.
The first step involves releasing free iodine from iodate by adding H_2SO_4. An excess of KI is added to help solubilize the free iodine, which is quite insoluble in pure water under normal conditions.
In the second step, the free iodine is titrated with thiosulfate. The free iodine is consumed by sodium thiosulfate during titration. The amount of thiosulfate used is proportional to the amount of free iodine released from the salt. Starch is added as an external (indirect) indicator of this reaction and reacts with free iodine to produce a blue color. When added towards the end of titration, the loss of blue color, or endpoint, which occurs with additional titration, indicates that all remaining free iodine has been consumed by thiosulfate.

Interpretation criteria

Algerian standards [30-50 ppm] (JORA 1990), as well as international standards [15-40 ppm] (WHO, 2007), for salt iodization were used for interpreting the results.

Statistical analysis

The software XLSTAT 2013.5 and SPSS® V24.0 were used. Results were expressed as median, mean, standard deviation, and extreme values for quantitative parameters. For qualitative parameters, results were presented as frequency percentages with a 95% confidence interval.

Results

The iodine content of household salt

The average iodine content of the salt was 21.74 ± 16.57 ppm, and the median content was 17.50 (8.14 - 31.71) ppm, which is below the required national median ranging from 30-50 ppm (Table 1 and Fig 1).

Table 1: Statistical analysis of iodine content in salt

Sex	Count	Salt iodine content (ppm)				
		Median (national standard: 30 – 50)		Mean		
		Value	1st Q – 3rd Q	Value	Standard deviation	Range
Total	509	17.50	8.14 - 31.71	21.74	16.57	1.19 - 98.25

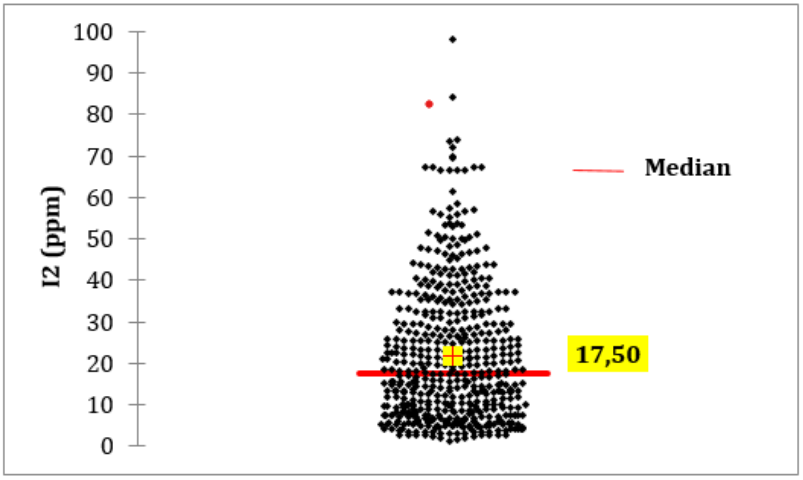


Figure 1: Scatter plot showing the distribution of iodine content in salt

Distribution of household salt iodine content according to iodine classes

The iodine content in the analyzed salt samples was 30 ppm in 73.67% of cases (n = 375). Only 19.25% (n = 98) were within the standards, and in 7.07% of cases (n = 36), the con tent was above 50 ppm, thus exceeding national standards (Fig 2).

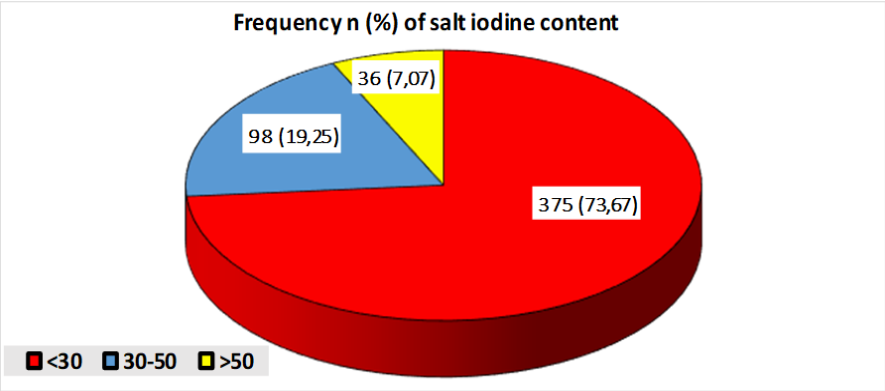


Figure 2: Distribution of household salt samples according to iodine content classes based on national standards

According to international standards (15-40 ppm), the iodine content of the salt analyzed in this study is below 15 ppm in 44.79% of cases (n=228). It falls within the standards, between 15-40 ppm, in 40.86% (n=208), and in 14.34% of cases (n=73), the iodine content of the salt is above 40 ppm, thus exceeding the standards (Fig 3).

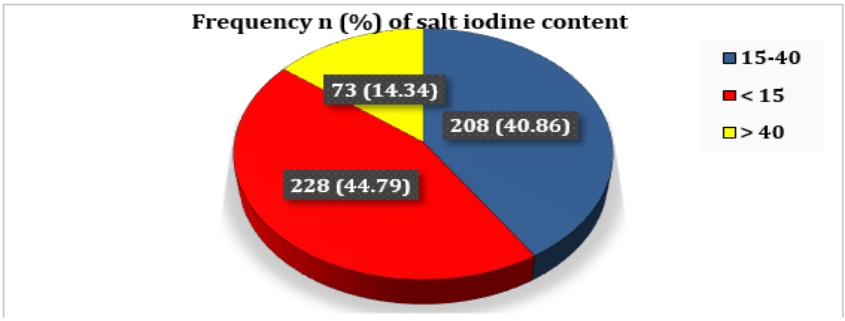


Figure 3: Distribution of household salt samples according to iodine content classes based on international standards (WHO)

Distribution of household salt by brand

The most consumed salt brand in this study is the private brand "Salt brand 17," accounting for 18.5% of cases. It is followed by the state-owned "Salt brand 2" at 15.7% and the private "Salt brand 19" at 10.6%. In 22.4% of cases, the specific salt brand could not be identified.

Most of the salt brands analyzed in this study contain iodine levels below 30 ppm, except for two brands with levels between 30 and 50 ppm, and one brand exceeding 50 ppm.

The iodine content of salt is not homogeneous within the same brand (10 salt brands), with low, average, or high iodine levels found within the same brand (Table 2).

Discussion

In Algeria, the January 1990 decree made it mandatory nationwide to use iodized salt for consumption at a rate of 30 to 50 ppm (JORA 1990). To protect consumers, a framework was established to ensure the quality control of iodized salt production and the distribution of properly packaged and labelled iodized salt (JORA 2019). According to WHO recommendations, the goal is to achieve a proportion of adequately iodized household salt > 90% (WHO 2007).

This study evaluated the actual State of iodized salt coverage in Bechar. Analyses of iodine content in salt found a median content of 17.50 mg/kg, below the national recommendations of 30-50 ppm. More than 80% of households use inadequate or excessively iodized salt. The iodine content is below 30 ppm in 73.67% of cases. In 7.07% of cases, the iodine content in salt is above 50 ppm, thus exceeding national standards, and only 19.25% are within standards (30-50 ppm).

According to international standards (15-40 ppm), the iodine content is below 15 ppm in 44.79% of cases, within standards in 40.86%, and above standards in 14.34% of cases, i.e., > 40 ppm (WHO 1994).

In 1995, 92% of households had adequately iodized salt (MSP and UNICEF 1996). This percentage dropped in 2000 when only 69% had it (MSP and INSP 2001). There were significant regional variations. In the southern region, less than half of households had it. In 2008, it was estimated that 69% of table salt was adequately iodized (WHO 2008).

Conversely, a study conducted in Sidi Bel Abbes showed that the iodine content of salt consumed in households met Algerian standards in 87.15% of cases, and only 12.85% did not meet them with either lower (7.85%) or higher (5%) iodine content (Rih et al., 2016).

A survey conducted three years later in Sidi Bel Abbes by the same team on a random sample of 738 households revealed that the iodine content of table salt was adequate for 53.12% of the total sample and non-compliant with Algerian standards in 46.88%, with levels below standards in 45.93% and above in 0.95%. Samples from the private sector were non-compliant in 91.05% of cases (Rih 2019).

A study at the University of Msila aimed at evaluating the iodine content of table salt sold on the national market found only 17.65% of commercial salts conforming to current standards. Conversely, 80.87% were non-compliant, with iodine levels below standards in 69.11% and above standards in 11.76% (Guerras and Ben Khaled 2019).

Table 2: Distribution of salt brands according to their iodine content

Salt brand	Samples tested n (%)	Iodine content in salt (ppm) n (%)		
		< 30	30 - 50	> 50
1 (private)	1 (0.2)	1 (100.0)	0	0
2 (state)	80 (15.7)	44 (55.0)	27 (33.8)	9 (11.3)
3 (private)	2 (0.4)	2 (100)	0	0
4 (private)	1 (0.2)	1 (100.0)	0	0
5 (private)	2 (0.4)	2 (100.0)	0	0
6 (private)	58 (11.4)	50 (86.2)	5 (8.6)	3 (5.2)
7 (private)	3 (0.6)	3 (100.0)	0	0
8 (private)	1 (0.2)	0	1 (100.0)	0
9 (private)	1 (0.2)	1 (100.0)	0	0
10 (private)	1 (0.2)	0	1 (100.0)	0
11 (private)	16 (3.1)	8 (50.0)	6 (37.5)	2 (12.5)
12 (private)	51 (10.0)	44 (86.3)	7 (13.7)	0
13 (private)	11 (2.2)	8 (72.72)	3 (27.27)	0
14 (private)	6 (1.2)	4 (66.7)	2 (33.3)	0
15 (private)	3 (0.6)	3 (100.0)	0	0
16 (private)	3 (0.6)	1 (33.33)	1 (33.33)	1 (33.33)
17 (private)	94 (18.5)	87 (92.6)	6 (6.4)	1 (1.1)
18 (private)	2 (0.4)	1 (50.0)	1 (50.0)	0
19 (private)	54 (10.6)	29 (53.7)	17 (31.5)	8 (14.8)
20 (private)	2 (0.4)	0	0	2 (100.0)
21 (private)	1 (0.2)	1 (100.0)	0	0
22 (private)	2 (0.4)	2 (100.0)	0	0
23 (Unknown)	114 (22.4)	83 (72.8)	21 (18.4)	10 (8.8)
Total	509 (100.0)	375 (73.7)	98 (19.3)	36 (7.1)

Above standards In the standards
Substandard Heterogeneous

The study conducted in eastern Algerian municipalities in 2021 aimed at evaluating the iodine content in packaged table salt sold commercially across twelve municipalities found an iodine content ≥15 ppm in 80.7% of samples collected from these municipalities, with excessive iodine (>40 ppm) present in 57.6%. An iodine content <15 ppm was noted in 16.7% of inadequately iodized samples. The absence of iodine was observed in 2.6% of cases (Hazourli et al., 2021).

Another study conducted in Oran in 2023 to determine iodine levels in commercial table salts found an average content of 10.07 ± 6.82 mg/kg of salt; iodine content varied within samples from the same brand. None of the local products contained the actual iodine content stated on their packaging, and none complied with Algerian regulations recommending between 50.55 and 84.25 mg of iodine per kilogram of salt (Zergui et al.,2023).

This reduction in iodized salt availability can be explained by lax control services allowing non-iodized salt with fraudulent labelling on the market.

According to our study results, Bechar still needs to achieve widespread coverage with adequately iodized salt. This contradicts IGN's data from 2017, which classified Algeria among countries with over 80% consumption of iodized salt (UNICEF 2017). This should alert public health authorities, primarily since the strategy for universalizing iodized salt with 30-50 ppm standards celebrated its thirtieth anniversary in 2020.

A study conducted in Benin in 2018 revealed that none of the salt samples met national iodization recommendations, with 40% having an iodine content of 0 ppm and all being microbiologically

contaminated (Mizéhoun-Adissoda et al. 2018). In Senegal, a study showed that 25% of salts were adequately iodized, while 50% were under-iodized and 25% were over-iodized (Diop et al., 2024).

New global data estimated that 89% of households worldwide consumed iodized salt in varying quantities and with different iodine concentrations (WHO 2022). Countries do not necessarily have the same minimum threshold for salt iodization. The lower limit of 15 ppm is required by WHO/UNICEF/ICCIDD (WHO 2007).

Indeed, salt loses 20% of its iodine from the production site and an additional 20% during cooking. With an average salt consumption of 10 g per person per day, the iodine concentration in salt at the production point should be between 20 and 40 mg of iodine per kg of salt (i.e., 20 to 40 ppm of iodine) to provide 150 µg of iodine per person per day (WHO 2007).

Humidity, grain size, the presence of impurities, storage method and duration affect the iodine content of salt (Assoumanou et al., 2011; Djonga et al., 2012).

Technological failures and post-production losses lead to uneven iodine distribution in salt, which is influenced by factors such as origin, storage, and packaging (Assey et al., 2009; Shawel et al., 2010).

Our results highlight that authorities have not succeeded in maintaining an effective long-term salt iodization program despite the national iodine fortification program. Additionally, this study made an important discovery by highlighting a need for uniformity in iodine content across different salt brands, raising concerns about the strategy used by producers for salt iodization.

Conclusion

Three decades after the decree mandating the consumption of adequately iodized salt at 30 to 50 ppm nationwide was adopted, this cross-sectional study evaluated the iodine content of salt consumed in households in Béchar. It found that the table salt consumed is not adequately iodized, falling below national recommendations. Disparities in iodine content were observed across different brands that could have health consequences. Strengthening strategies and monitoring at various levels can help detect and correct anomalies to protect consumers.

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Conflict of interest

There is no conflict of interest to be declared.

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