Iodine content in the produced and marketed iodized edible salt in Semnan providence, the primary salt-producing province in Iran

Hamidreza Hafezi[1], Ali Nikmanesh[1], Sajjad sadeghi*[1]
[1]*Food & Drug Administration, Semnan University of Medical Sciences, Semnan, Iran*
* *Corresponding Author: Dr. Sajjad Sadeghi, Food & Drug Administration, Semnan University of Medical Sciences, Semnan, Iran. Tel. +98 23 33334808*

Abstract Background: Iodine deficiency represents a significant global public health issue, as it can result in Iodine Deficiency Disorders. Worldwide initiatives have diminished the incidence of these disorders in numerous areas via Universal Salt Iodization. The purpose of this study was to evaluate the iodine content in salt samples manufactured and distributed in Semnan Province, Iran.

Methods: A total of 373 salt products, available in markets and produced by factories in the Semnan province of Iran, were collected. The samples were analyzed to determine iodine concentration using a titration instrument, in accordance with the standards of the Iranian National Standardization Organization No. 3696 and Codex Alimentarius.

Results: Iodine was found in 86.6% of edible iodized salt samples at a standard concentration, with a mean ± SD of 40.93±12.07 mg/kg. The iodine concentration ranged from a minimum of zero to a maximum of 90.71 mg/kg.

Conclusions: The article primarily indicated that the majority of salts produced and marketed in Semnan province contain iodine concentrations within the standard range.

Keywords: Iodized salts, Iodine content, Semnan, Iran.

I. Introduction

Iodine, a vital micronutrient, is key to the proper development of the central nervous system and thyroid function [1]. It regulates essential bodily functions including temperature, growth, and reproduction [1]. Iodine is found in various chemical forms, primarily as iodide (the ion form of iodine) and iodate (a salt or ester of iodic acid) [2]. Iodine deficiency presents a significant global public health concern due to its potential to cause Iodine Deficiency Disorders (IDD), including impaired cognition in children, cancer, and developmental disease [3-5]. excessive iodine intake also lead to thyroid disorder and cancer [5]. Methods such as incorporation of iodine in salt have effectively addressed iodine deficiency, leading to global progress in iodine intake [4, 6]. Global efforts have decreased the prevalence of iodine deficiency disorders in numerous regions, through Universal Salt Iodization (USI) [7]. Some studies have shown that Iran has successfully USI-implemented a 29-year national salt iodization program, resulting in sufficient iodine intake among the population [8-10]. More than 98% of households consume iodized salt in Iran, meeting the criteria set by the World Health Organization (WHO) [9]. The general population in Iran has sufficient iodine levels, leading to Iran declaring itself iodine deficiency disorder-free in 2000 [8, 10]. The prevalence of goiter decreased significantly after 17 years of iodization in Iran [11]. Some provinces lack adequate iodine nutrition and require special attention in Iran [12]. It should mention, both lack of iodine and excessive iodine intake can cause health problems so periodic monitoring of population iodine status is important for ensuring sufficient intakes [7]. Given the importance of continuous measurement of iodine concentration in salt, this study aimed to evaluate iodine concentration in the produced and marketed salt samples in Semnan Province, the primary province for salt production in Iran.

II. Materials and Methods

2.1. Sampling

A total of 373 samples were randomly collected from five cities in Semnan province, namely Semnan, Garmsar, Damghan, Mahdishahr, and Sorkheh, between March 2020 and March 2024. These samples were all sent to the Food and Drug Control Laboratory at Semnan University of Medical Sciences. Of these, 106 samples were purchased from markets, while 267 were acquired from Salt Production Factories.

2.2. Reagents

We used three reagents as follows: 1- Titrant: sodium thiosulfate c(Na2S2O3) 0.01 mol/L (0.02 normal) 2- Sulfuric acid 2 Normal 3- Potassium iodide 10% w/v.

2.3. Sample preparation

Similar to previous research [13], all samples were analyzed for iodine concentration at the Food and Drug Control laboratory, following the guidelines of the Iranian National Standardization Organization (INSO) No.3696, the Combined Compendium of Food Additives Specifications [14], and the Codex Alimentarius monograph [15].

12.5-gram sample was weighted out into a breaker and dissolved in approx. 65 mL of distilled water. Then, 1 mL of sulfuric acid (2N) and 5 mL of potassium iodide solution (10%) were added and allowed to react for 2 min under stirring, turning the solution yellow. The breaker was sealed and placed in a dark area for 10 minutes.

2.4. Analysis and calculations

The iodine released in the solution was titrated after the initial point using sodium thiosulfate (0.02 N) through automated titration methods (Titrando 906, Metrohm, Switzerland) and was managed with Taimo software (version 2). Titrando comprised three instruments: 1- Pt Titrode 6.0431.100 2- Electrode cable 6.2014.020 3- Dosing unit 6.3032.2020.

The total iodine content is expressed in mg/kg (ppm). One milliliter of 0.01 mol/L c(Na2S2O3) is equivalent to 0.2115 mg of iodine. The final equation is presented below:

$$total\ iodine\ (ppm) = EP1 \times 0.2115 \times 1000 \times \frac{Titter}{sample\ size}$$

In this calculation formula, EP1 represents the milliliters of c(Na2S2O2) up to the endpoint, the sample size is the weight of the sample in grams (12.5 gr), 1000 is for 1 kg, and Titer is the titer number of the c(Na2S2O2) solution.

2.5. Method validation procedures

All of the samples were analyzed with the validated automated titrator techniques which fitted with a platinum electrode was applied. The iodine detection method was pre-validated at the Food and Drug Control laboratory. Linearity of the method was assessed using a graph plotting iodine concentrations. The graph depicted analyte concentrations at five levels (0, 15, 30, 60, 120 mg/kg), each with three replicates (Fig. 3). A regression line was drawn, yielding a correlation coefficient ($R^2 = 0.9990$) through the least squares method, to evaluate the relationship between the actual area and the measured iodine concentration.

2.6. Statical analysis

Quantitative data are presented as mean ± SEM, and qualitative data are expressed as percentages (n%). All analyses were performed using Prism 9 GraphPad software. Differences in quantitative data between groups were assessed using one-way ANOVA followed by Tukey's post-hoc test. A two-tailed p-value of less than 0.05 was considered statistically significant.

III. Results

The current study utilized titrator techniques to detect iodine levels in iodized salt samples. The results, as presented in Table 1, indicate that the majority of samples fell within the standard iodine range (Mean ± SD; 40.93±12.07). Specifically, 86.6% of the samples contained iodine within the standard range (30-60 mg/kg), while the remaining 13.4% had iodine levels outside the standard range. The iodine concentration ranged from a minimum of zero to a maximum of 90.71 mg/kg.

Table 1; Iodine detected in produced and marketed edible iodizied salt samples

Parameters	Origine of samples		Total (precent)
	Markets	Salt Production Factories	
Number of Samples	106	267	373
Mean Iodine Content ± SD (mg/kg)	39.64±13.88	41.45±11.26	40.93±12.07
Samples with Iodine Content < 30 mg/kg	16 (15%)	25 (9%)	41 (11%)
Samples with Iodine Content > 60 mg/kg	1 (1%)	8 (3%)	9 (2.4%)
Samples with Normal Iodine Content (30-60 mg/kg)	99 (84%)	234 (88%)	323 (86.6%)
Minimum Iodine Content (mg/kg)	0	3.23	0
Maximum Iodine Content (mg/kg)	80.85	90.71	90.71

No significant variations are observed in the iodine concentration of iodized salt samples across different years and seasons (refer to Fig. 1 and 2).

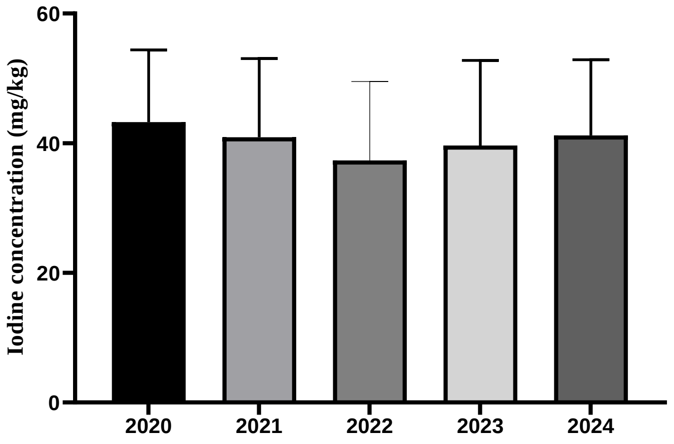

Figure 1: The iodine concentration in the iodized salt sampls by years. Values are expressed as the mean ±SEM. Data were analyzed by one-way ANOVA multiple comparison test followed by Tukey's multiple comparison tests. (p-value > 0.05)

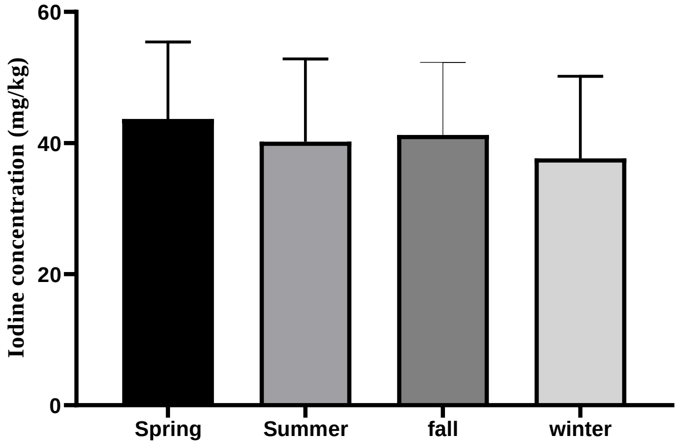

Figure 2; The iodine concentration in the iodized salt sampls by seasons. Values are expressed as the mean ±SEM. Data were analyzed by one-way ANOVA multiple comparison test followed by Tukey's multiple comparison tests. (p-value > 0.05)

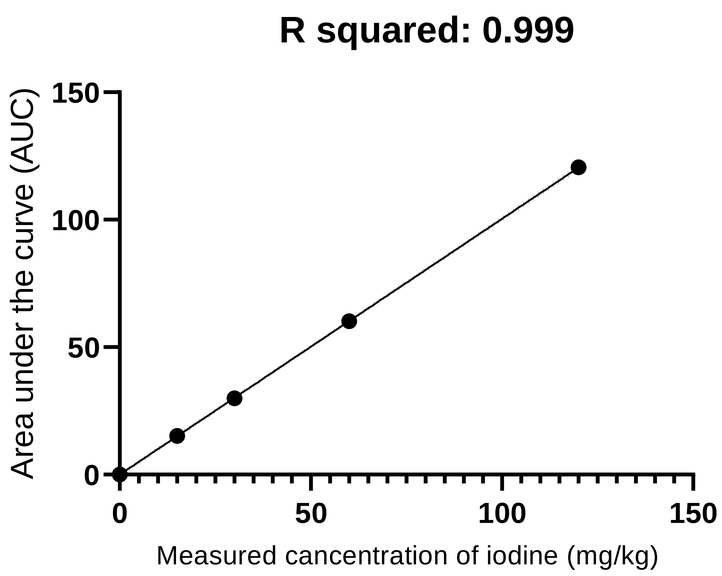

Figure 3: Linearity plot for five different concentrations of Iodine using automated titrator instrument.

IV. Discussion

The current study revealed that 13.4% of iodized salt samples were outside the standard iodine range. Specifically, 11% had iodine concentrations below the standard threshold, while 2.4% exceeded it. It is important to note that both insufficient and excessive iodine intake can lead to health issues. In Iran, studies on the monitoring of salt's iodine levels indicated that 49% had iodine concentrations beyond the standard limit (Table 2). Consequently, the iodine content in consumable iodized salt raises concerns, necessitating additional research and regulatory scrutiny.

Table 2: Condition of iodine in iodized salts in Iran

Province	Number of salt samples were out of standard range for iodine	year	reference
Markazi (Center of Iran)	50%	2020	[16]
Qom (Center of Iran)	48.33%	2017	[17]
Lorestan (West of Iran)	35.41%	2015	[13]
Kermanshah (Center of Iran)	50%	2013-2014	[18]
Khorasan-e-Razavi (East of Iran)	32.8%	2010-2015	[19]
Tehran (Center of Iran)	56.08%	2010	[20]
Tabriz (North of Iran)	44.1%	2006	[21]
Semnan (Center of Iran)	31.2%	2004	[22]

Bushehr (South of Iran)	89%	2000	[23]

Iran and some countries like Croatia have successfully implemented USP, emphasizing the importance of monitoring iodine intake to prevent deficiencies and excesses [8, 10, 24]. Studies indicate that Iranian salt intake remains high (9.52 g/day, double WHO recommendation) [21, 25-27]. One possible reason for the success of the national USP, despite the existence of non-standard iodine levels in some salts, could be the high consumption of salt by Iranians. This high consumption, while potentially harmful, may help compensate for the lack of iodine in iodized salt. However, challenges persist in ensuring sufficient iodine levels, particularly during pregnancy and in young people [6, 28]. Iodine supplements can improve fetal neurodevelopment, but their effect on maternal thyroid function is inconclusive [29, 30]. In light of the findings, conducting further research and establishing a serious audit for producing edible iodized salt is recommended.

V. Conclusion

This article mainly presented that most of produced and marketed salts in Semnan province has iodine concentration in standard range.

Ethical Considerations: All ethical principles were considered in this article.

Funding: No finding

Conflict of interest: The authors declared no conflicts of interest.

Acknowledgements: The authors wish to thank all technical staff of the analytical laboratory of Food and Drug Administration, Semnan-Iran for their invaluable assistance.

References

[1]. Prasad, M.N.V., *Iodine Essentiality for Human Health: Sources, Toxicity, Biogeochemistry, and Strategies for Alleviation of Iodine Deficiency Disorders.* Medical Geology: En route to One Health, 2023: p. 155-174.

[2]. Espino-Vázquez, A.N., F.C. Rojas-Castro, and L.M. Fajardo-Yamamoto, *Implications and practical applications of the chemical speciation of iodine in the biological context.* Future Pharmacology, 2022. **2**(4): p. 377-414.

[3]. Zimmermann, M.B., *The remarkable impact of iodisation programmes on global public health.* Proceedings of the Nutrition Society, 2023. **82**(2): p. 113-119.

[4]. Opazo, M.C., et al., *The impact of the micronutrient iodine in health and diseases.* Critical reviews in food science and nutrition, 2022. **62**(6): p. 1466-1479.

[5]. Winder, M., et al., *The impact of iodine concentration disorders on health and cancer.* Nutrients, 2022. **14**(11): p. 2209.

[6]. Nedić, O., *Iodine: Physiological importance and food sources.* eFood, 2023. **4**(1): p. e63.

[7]. Bertinato, J., *Iodine nutrition: Disorders, monitoring and policies*, in *Advances in Food and Nutrition Research*. 2021, Elsevier. p. 365-415.

[8]. Sovid, M., M. Bahmani, and A. Aamsami, *Is it necessary to recommend iodine supplement to pregnant women living in areas with adequate iodine intake?* Shiraz E-Medical Journal, 2020. **21**(10).

[9]. Saeidlou, S.N., et al., *Has iodized salt reduced iodine-deficiency disorders among school-aged children in north-west Iran? A 9-year prospective study.* Public Health Nutrition, 2018. **21**(3): p. 489-496.

[10]. Delshad, H., et al., *Continuously sustained elimination of iodine deficiency: a quarter of a century success in the Islamic Republic of Iran.* Journal of Endocrinological Investigation, 2018. **41**: p. 1089-1095.

[11]. Delshad, H., et al., *Goiter and urinary iodine excretion survey of schoolchildren in Qazvin provine: results of 17 years universal salt iodization in Iran (2007).* 2011.

[12]. Moshrefi, B., H. Delshad, and L. Karimzadeh, *Iodine Fortification Program Effectiveness: A Review on National Studies of Iodine Fortification.* Clin Exc, 2015. **4**(1): p. 174-57.

[13]. Sepahvand, R., et al., *Iodine concentration in iodized salts marketed in Lorestan Province, West of Iran.* Journal of Chemical Health Risks, 2018. **6**(2).

[14]. Joint, F. and W.E.C.o.F. Additives, *Combined compendium of food additive specifications*, in *Food additives PZ*. 2018.

[15]. Commission, J.F.W.C.A., *Codex alimentarius monograph*. 2018: Food & Agriculture Org.

[16]. Javaheri, J., et al., *Evaluation of iodine salt intake, salt storage, and urinary iodine among the households in Markazi Province, Iran.* Chronic Diseases Journal, 2020: p. 190-196.

[17]. Mohammadbeigi, A., et al., *Evaluation of the accessible level of iodine in marketed iodised salt in Iran: A comparison with standard recommended values.* Advances in Human Biology, 2019. **9**(1): p. 42-45.

[18]. Pasdar, Y., et al., *Iodine content in salt used in Kermanshah, 2013-2014.* Journal of Mazandaran University of Medical Sciences, 2016. **26**(135): p. 144-148.

[19]. Ramezani Awal Riabi, H., et al., *Comparing the quality of iodine in edible salt in Iranian households living in the southern province of Khorasan-e-Razavi Using WHO Standards (Years 2010–2015).* Journal of Food Quality, 2017. **2017**.

[20]. Nazeri, P., et al., *Evaluation of iodine nutritional status in Tehran, Iran: iodine deficiency within iodine sufficiency.* Thyroid, 2010. **20**(12): p. 1399-1406.

[21]. Kousha, A., et al., *Monitoring and enforcement of the salt iodization programme in Tabriz, Islamic Republic of Iran: a successful experience.* EMHJ-Eastern Mediterranean Health Journal, 16 (5), 528-532, 2010, 2010.

[22]. Mehdinia S.M., N.H.R., Gharib-boloukeh and A.R. R., Rezaei M, *Check the amount of iodine in iodized salt distributed in Semnan province in autumn.* J Med Sci, 2004. **6**(4): p. 290-285.

[23]. Mohammadi M.M., G.-s.H.R., Mohammadi-baghmolaei M., *Check the amount of iodine in edible salt fortified with iodine and salt is not rich in Bushehr in 2000.* South Med J, 2000. **3**(2): p. 112-107.

[24]. Vasiljev, V., et al., *Overview of iodine intake.* Southeastern European Medical Journal: SEEMEDJ, 2022. **6**(1): p. 12-20.

[25]. Pouraram, H., et al., *What do we need to start a multimedia salt reduction campaign?* International Journal of Preventive Medicine, 2023. **14**(1): p. 28.

[26]. Amerzadeh, M., et al., *Policy analysis of socio-cultural determinants of salt, sugar and fat consumption in Iran.* BMC nutrition, 2022. **8**(1): p. 26.

[27]. Gholami, A., et al., *National and sub-national trends of salt intake in Iranians from 2000 to 2016: a systematic analysis.* Archives of Public Health, 2022. **80**(1): p. 120.

[28]. Hess, S.Y. and E.N. Pearce, *Iodine: Physiology, dietary sources, and requirements.* 2023.

[29]. Ferreira, L.M., *THYROID HEALTH, PREGNANCY AND IODINE SUPPLEMENTATION.* Health and Society, 2022. **2**(03): p. 132-177.

[30]. Delshad, H., et al., *Iodine supplementation for pregnant women: a cross-sectional national interventional study.* Journal of Endocrinological Investigation, 2021. **44**: p. 2307-2314.