Journal of Natural Science Review

Vol. 2, No. 2, 2024, 47-59
https://kujnsr.com
e-ISSN: 3006-7804

Determination of Iodine Content of Different Brands of Edible Iodized Salts Available in Kabul City, Afghanistan

Bashir Ahmad Bashir[1]✉, Gull Nazir Nazimi[2], Noorullah Mandizi[3]

[1] Kabul University, Nutrition and Food Analysis Department, Faculty of Pharmacy
[2] Kabul University, Chemical Department, Faculty of Chemistry
[3] Dawat University, Biochemistry Department, Faculty of Pharmacy
✉Email: bbbasherahmad@gmail.com (corresponding author)

ABSTRACT

Salt is an excellent carrier of iodine since it is consumed by all community members at approximately consistent, well-defined levels, regardless of socio-economic condition. Iodine is an essential micronutrient of thyroid glands for average growth and mental development. Iodine deficiency is a common problem in some parts, especially in mountainous fields of Afghanistan, and causes specific diseases. One of the essential ways to prevent Iodine deficiency disease is to fortify edible salt with iodine. This research aims to find out how much iodine was in various brands of edible table salts sold at the retailer level in various Kabul shopping centers. This cross-sectional research was performed from 15 July to 15 August 2023. The iodometric titration method determined Iodine in salt samples—23 different brands. We have found 39% of selected samples that are not standard in amount of iodine content. Also, marked samples were found to be 17% without iodine, and 43% had a sufficient amount of iodine. Determination of iodine content in salt samples showed that more than 50% of the powdered samples don't have adequate iodine content (15 ppm and above). That means advice on powdered salt use does not ensure the proper iodine intake.

ARTICLE INFO

Article history:
Received: May 23, 2024
Revised: June 11, 2024
Accepted: June 22, 2024

Keywords:
Iodine; Iodine deficiency; Iodized salt; Iodine deficiency disorder

To cite this article: Bashir, B. A., Nazimi, G. N., & Mandizi, N. (2024). Determination of Iodine Content of Different Brands of Edible Iodized Salts Available in Kabul City, Afghanistan. *Journal of Natural Science Review, 2*(2), 47-59. DOI: https://10.62810/jnsr.v2i2.60
To link to this article: https://kujnsr.com/JNSR/article/view/60

Introduction

Salt is an excellent carrier of iodine as everyone consumes salt at relatively constant, well-defined levels regardless of socio-economic condition. Specific amounts of dry solid or liquid potassium iodate or iodide are added to iodized salt. Potassium iodide is not as stable as potassium iodate because it can be oxidized by oxygen and other substances. The potassium iodate-containing salts maintained a significant portion of their initial iodine content even after heating, whereas the potassium iodide-iodized salts lost a significant proportion of iodine. The global success program of salt iodization is recommended by WHO, UNICEF, and GAIN because:

- In general, salt is used by all members of the society every day.
- The technology of enriching salt with iodine is simple.
- The iodization of salt does not change the taste of the sale(WHO, 2021).

Research was conducted in Oman to evaluate iodized salt in Muscat. This research shows that some samples' Iodine levels were lower than recommended (Halligudi, 2022; Kostova et al., 2022) evaluated the iodine in iodized salt. Results indicate a lower level of iodine than the standard level.

Lieberman et al. *(2022)* made it clear that the fortification of table salt began in the 1920s, when the deficit was evident throughout the U.S. Around 1990, salt iodization initiatives were implemented and have globally reduced the prevalence of iodine shortage in many populations, however currently 30% of the world's population is at danger of iodine deficiency. In 2020, 122 countries had legislation for iodization of salt as mandatory. The Recommended Dietary Allowance (RDA) for adult men and women is 150 µg/day. The term "recommended dietary allowance" (RDA) refers to the average daily intake of iodine that is needed to meet the dietary needs of about 97.5% of healthy adult(Lieberman, 2022).

Iodine is a trace and an essential element vital to human health. The thyroid gland uses iodine to produce the hormones thyroxin (T4) and tri iodothyronine (T3), which control how the body metabolizes its physiological processes. The need for Iodine starts from the embryonic time. If a pregnant woman does not get enough iodine daily through food, it will cause severe problems for herself and her baby. Iodine is a micronutrient of thyroid glands for normal growth and mental development with an average requirement of 100 to 150 µg /day. Approximately 2 billion people have Iodine deficiency (Charles, 2023). However, iodine intake, whether high or low, can lead to thyroid disorders, which are detrimental to human health. Iodine Deficiency Disorders (IDD) and hypothyroidism are caused by the human body's inability to synthesize thyroid hormones due to a lack of iodine in the diet. Because of iodate's excellent bioavailability and stability, it is used to iodize salt samples. Consuming iodized salt ensures a proper iodine intake(Wisnu C., 2008). Iodine is necessary for the thyroid to produce the hormones because Iodine regulates the body's general metabolic response. In the last two decades, people have learned enough about the importance of iodine for health and diseases caused by iodine deficiency. Today, all health organizations worldwide have realized that the solution to iodine deficiency is to enrich table salt with iodine (Szybiński, 2012).

When the thyroid glands do not create enough thyroid hormones, the disease known as hypothyroidism occurs, resulting in a decrease in the blood level of thyroid hormone. A variety of functional and developmental disorders, including endemic goiter, abortions, stillbirths, cretinism, delayed physical development, brain damage, and permanent menstruation, are included in iodine deficiency diseases. Overconsumption of iodine in food and water can also lead to long-term adverse health effects, including thyrotoxicosis, thyroiditis, goiter, and thyroid papillary carcinoma. Salt iodization is considered the most effective long-term public health intervention for achieving optimal iodine nutrients; effective salt iodization is a prerequisite for the sustainable elimination of iodine deficiency disorders like retarded mental and physical development, hypothyroidism, endemic goiter, reproductive failure, and childhood mortality (WHO, 2021).

Many large-scale studies conducted worldwide have shown increased hyperthyroidism, followed by iodization. Determining their iodine concentrations is essential to decide whether or not they follow the recommended level of fortification at the time of manufacture. Given that iodine status and iodine exposure are comparable, iodine status can be used directly to determine the risk of iodine exposure and, in turn, indirectly, to forecast population health (Prakash, 2005).

Research was carried out to evaluate the iodine in commercial edible iodized salts to ascertain the concentrations of iodine in commercial edible salt products sold in the market. Also, an investigation showed how iodine's availability changes depending on how it is cooked and exposed to air, and consumer iodine status was evaluated to estimate the risks of iodine deficiency. Iodization programs have been successfully implemented in Afghanistan. Afghanistan started to fortify salt with iodine in 2003, and it became mandatory there in 2011. Since then, 32 producers across 14 provinces have significantly increased the national capacity to produce iodized salt (Poyesh et al., 2015).

In addition to children, pregnant women are more susceptible to iodine deficiency. Iodine deficiency causes significant metabolic alterations linked to the first half of pregnancy. This explains why a pregnant woman experiencing iodine deficiency would have increased thyroid gland activity(Untoro et al., 2007; Koyuncu et al., 2019; Verhagen et al., 2020).

The World Health Organization advised 150 micrograms per day for adults, 250 for preg nant women, and 120 micrograms per day for children(Voltaire, 2021). Initially, adding iodine to salt to control endemic goiter was recommended, but *Kimball* et al. (1920) used iodized salt to prevent thyroid gland enlargement in Michigan, USA. The performance of the above heartens us to evaluate the iodized salts. All products can be found in Kabul markets. Therefor many brands of iodized salts are present in the markets of Kabul city.

Materials and Method

Materials: Different brands of Iodized salt, Sulphuric acid, Potassium Iodide, Sodium thiosulphate, and Starch solution were used as indicators. All reagents were ANALAR brand and laboratory grade. Also, all reagents were purchased with personal funds (Thippeswamy , 2022; Ashwini, 2013).

Method

This cross-sectional research was carried out from 15 July to 15 August. The iodized edible population of study: Different brands of edible iodized salt have been considered. At the time of the research, only 23 types of edible salts with different brands were available in the markets of Kabul city, which were included in the study.

Study area

Area: This research includes only 23 municipal districts of Kabul city, not including the districts and villages of Kabul city.

Samples

Convenience non-probability sampling techniques were used to select the study subjects. Twenty-three different brands of iodized salt samples in crystal and acceptable powder forms were randomly collected from all markets in Kabul. The wholesomeness of the container (to protect iodine from air and light) and label were considered thoroughly for manufacture, expired date, and other claims on the salt containers. Several methods have been applied for determining iodate in iodized salt; however, most methods do not precisely determine and separate the iodine species. Iodometric titration is often used to analyze iodate, not only to assess potassium iodate but also to determine all oxidation in the solution that may cause an increase in the iodine ingredient in iodized salt. In research, the amount of iodine in iodized salts during cooking was determined by the iodometric method in Indonesia, and it showed that the bioavailability of iodate is better than iodide (Wisnu C., 2008).

The iodometric titration method was used to determine the iodine content of iodized salt in South Africa. The result indicated that only 30.9% of iodized salt samples had adequate Iodine (Pieter L., 2003). The Iodometric titration method will include free Iodine liberation and titration by sodium thiosulfate. Considering iodine's(iodate salts) resistance to heat and humidity, 10 g of salt samples are usually taken, and each is dissolved in a measured amount of deionized distilled water for analysis(Zahidi, 2016). Based on the research conducted at the Tumkur University of India, eight different brands of iodized salt were evaluated according to the effect of expired date on iodine quantity in iodized salt. The result of the investigation indicated that the amount of iodine in three samples had decreased after the expiration time (Jalili et al., 2018 ; Thippeswamy, 2022).

Using previous research on the evaluation of iodized salts, we also used the Iodometric titration method, the manual method in the laboratory, to measure the quality of iodized salt. Twenty-three different salt samples were collected and transported to the laboratory in a moisture-free, clean, airtight plastic container. During sampling, two primary sources of salt were discovered: unpackaged salt and packaged salt. All unpackaged samples were removed, and all packaged iodized salt was collected, marked, and coded with the following details:

Manufacture and expiration date of the samples, salt supplier, batch number, iodine content, and other study-related information. Throughout the investigation, all samples were stored in regulated circumstances. All collected samples were kept at room temperature.

The iodometric titration required using several reagents, including standardized sodium thiosulphates (titrant), starch solution as an indicator, and H_2SO_4, KIO_3, and KI as primary reagents. The iodometric titration method, considered the gold standard, was used for the laboratory test. Each sample was examined three times, and the average of those results was the sample's iodine concentration. Iodate in iodized salt can be measured using a variety of techniques. Iodate in iodized salt can be measured easily using iodometric titration. Intra-assay precision and inter-assay precision were considered(Kumarl, 2013).

Principle: Every chemical interaction is based on a principle. Knowing the principle is essential for the analyst**.** The idea is that iodine can be released by adding sulphuric acid to a solution of iodized salt. To keep the iodine dissolved, a potassium iodide solution is added. Following iodine liberation, sodium thiosulphate titration is performed. Starch is used as an indicator. The following is a summary of the chemical interactions involved in this process:

1.	IO_3 (from salt)	+	$5I^-$	+	$6H^+$ (from KI)	(from H_2SO_4)	→	$3I_2 + 3H_2O$
2.	$2Na_2S_2O_3$ Sodium thiosulfate	+	I_2 Iodine	→	$2NaI$ Sodium iodide	+		$Na_2S_4O_6$ Sodium tetrathionate

Figure 1. Iodometric reaction (Pieter L., 2003 **;** Halligudi, 2022)**.**

Preparation of reagents

1. Sodium thiosulphate solution 0.005N: 1.24 grams of sodium thiosulfate should be dissolved in one liter of double-distilled water. Keep in a cool, dark location.
2. Standard potassium iodate solution 0.005 N: 0.635 grams of KIO_3 should be dissolved in one liter of double-distilled water. Store in a dim location.
3. Sulphuric acid 2N: The molecular weight of sulfuric acid is 98, and active valance is 2. Its specific gravity is 1.8. So, for 100 ml of 2 N sulfuric acid solution, 5.45 ml 98% is needed.
4. Potassium iodide 10%: 10 gm of KI should be dissolved in 100 ml water.
5. Starch solution 1%: first, add 1g of starch in 50 ml water, then add it to 50 ml of boiling water. The total volume reached 100ml.

Standardization of sodium thiosulphate solution

1. A standard potassium iodate solution must be added to establish the normality of the sodium thiosulphate solution.
2. Take a burette filled with sodium thiosuphate solution 0.005N.
3. Pipette 25ml of potassium iodate standard at 0.005N into a conical flask. 5 ml of KI and 1–2 ml of 2N H_2SO_4 should be added.
4. To make the solution (of released iodine) pale yellow in hue, titrate the solution with sodium thiosulphate.

5. 1 ml of the starch solution should be added. The solution turns a rich purple color.
6. Pour the thiosulphate solution drop by drop until the purple color is gone from the burette. This formula is used to determine sodium thiosulphate normality:

$N_1V_1=N_2V_2$: When the normality of two solutions is equal, they interact with each other with equal volume.

Volume of $Na_2S_2O_3$ (V_2) x Normality of $Na_2S_2O_3$ = Volume of KIO_3 (V1) x Normality of KIO3 (N_1) (N_2) Normality of sodium thiosulphate

$$N_2 = \frac{V_1N_1}{\mathbf{V_2}}$$

The 10% potassium iodide reagent stock should be kept away from direct light, and the reaction mixture (after the addition of sulfuric acid and potassium iodide) should be kept in the dark before titration to avoid a side reaction in which iodide ions are oxidized to iodine when these solutions are exposed to light. (Fallah et al., 2020).

Procedure

In 100 ml of distilled water, 10 g of salt was dissolved. Next, 2 ml of 1 M (Molar) sulfuric acid and 5 ml of 10% (m/v) KI solution were added, and the mixture was immediately sealed. After thoroughly shaking, the mixture was left in a dark place for five minutes. Then, 2 ml of a 1% starch solution was added after the solution had been titrated with a standard sodium thiosulfate solution (Na_2S_2O3) of 0.005 M until a light straw yellow color was achieved. The titration was restarted until the endpoint was colorless. The total iodine content of each product was then calculated. After performing a blank determination with 10 g of analytical grade Nacl as a control, the iodate contents of iodized salts were measured in triplicates using iodometric titration. The following formula was used to calculate the number of ppm of iodine in the salt assay:

$$\text{Iodine ppm} = \frac{R \times 100 \times 1000 \times 0.127 \times N}{6}$$

R: used thiosulphate volume.

100**:** for converting the result for 1000g of salt

1000**:** for converting the gram of iodine to milligram

0.127: is the weight of iodine equivalent to 1ml of normal thiosulphate solution

N**:** normality of thiosulphate (which is 0.005N)

6**:** is to find the value corresponding to one liberated iodine atom.

To convert iodine to KIO_3, multiply the iodine ppm by 1.685.

$$\text{Mg /kg (ppm) iodine} = \frac{\text{The volume of sodium thiosulfate is used} \times 21.15 \times \text{normality of } KIO_3 \times 1000}{\text{Weight of sample}}$$

or

$$\text{Iodine (ppm)} = \frac{\text{Titration volume (ml)} \times 21.15 \times \text{Normality of Sodium thiosulphate} \times 1000}{\text{Weight of Salt (g)}}$$

***Determination of pH**:* 1 gram of edible salt is dissolved in 30 ml of water, and the PH of 23 salt pH brands was measured using a pH meter(Halligudi et al., 2022). Using the Excel program, their average price has been included in the results.

Findings

This research shows that different brands of iodized salts with varying amounts of iodine are available in the markets of Kabul city. Some samples were not based on the standard (15 ppm and above). Also, as a result, it became clear that even iodized salts with different brands do not contain iodine. The difference in the amount of iodine in another salt brand indicates that advice on iodized salt use does not ensure adequate iodine intake. To avoid repeating the names of the collected salts, all the samples were coded.

The results obtained from the analysis of iodized salts are arranged in separate tables.

Table 1: Specification of iodized salts samples (n= 23)

Code number	Product name	Specification	Ingredient
001	Madina	Iodized mark, grounded	Not mentioned
002	Sehat-e- shuma	Iodized, mark, crystal	Sodium chloride, water-insoluble, Calcium, iodine, magnesium, Iron,
003	Omid-e- Kabul	Iodized mark, Grounded	Not mentioned
004	Soner	Iodized, mark, crystal,	Potassium iodate, potassium Ferro cyanide
005	Boston-e sehat		
006	Omind-e- Kabul	Grounded, Iodized mark	Not mentioned
007	Watan	Grounded, Iodized mark	Not mentioned
008	Akhter sehat	Grounded, Iodized mark	Copied of code 002
009	Sehat-e-nasrat	Grounded, Iodized mark	Copied of code 002
010	Naveed	Grounded, Iodized mark	Not mentioned
011	Sehat	Grounded, Iodized mark	Not mentioned
012	Aetebar-e- shuma	Grounded, Iodized mark	Not mentioned
013	Paris salt company	Grounded, Iodized mark	Not mentioned
014	Scocdeh	Grounded, Iodized mark	Not mentioned

015	Ariana-e- Zeba	Grounded, Iodized mark	Not mentioned
016	Shifa	Grounded, Iodized mark	Copied of code 002
017	Sehat	Grounded, Iodized mark	Not mentioned
018	Nafice	Grounded, Iodized mark	Not mentioned
019	Khaibar sehat	Grounded, Iodized mark	Not mentioned
020	Sehat	Grounded, Iodized mark	Not mentioned
021	Sehat-e- watan	Grounded, Iodized mark	Not mentioned
022	Bostan-e- sehat	Grounded, Iodized mark	Copied of code 002
023	Spin ghar	Grounded, Iodized mark	Not mentioned

Table 1 explains that among 23 different brands, only two samples are crystal, and all others are powdered, but all are marked as Iodized salt. Codes numbers 002 and 004 mention the ingredients of the packages. Codes number 008,009,016, and 022 have copies of the label number 002. Only 6.8% have mentioned the contents of the packages, 17.3% of packages are copied, and 73.9% haven't mentioned the ingredients.

The pH of salt is usually 7. Salts are formed when a cation replaces the H+ ion of the acid, and the H+ ion, which causes the pH to be low, is combined with OH- ions to form water or is released as H2 gas. Thus, the salt is not acidic, and the pH of the salt is 7.

Table2: pH and Iodine content of salt samples (n=23).

Code number	Product name	Place of production	Amount of iodine as ppm	pH
001	Madina	Jalalabad	Don't have iodine	6.3
002	Sehat-e- shuma	Mazaar-e- sharif	16.18	6.2
003	Omid-e- Kabul	Kabul	12.11l	6.5
004	Soner	Iran	15.23	5.7
005	Boston-e sehat	Jalalabad	14.12	6.1
006	Omind-e- Kabul	Kabul	12.23	5.8
007	Watan	Kabul	13.11	5.7
008	Akhter sehat	Kabul	11.10	6.3
009	Sehat-e-nasrat	Jalalabad	12.14	6.5
010	Naveed		15.12	6.7
011	Sehat	Jalalabad	15.12	5.8
012	Aetebar-e- shuma	Kabul	15.12	5.9
013	Paris salt	Jalalabad	12.12	6.3
014	Scocdeh	Kabul	20.11	6.7
015	Ariana-e- Zeba	Kabul	15.13	6.9
016	Shifa	Jalalabad	11.14	6.4
017	Sehat	Kabul	13.23	6.6
018	Nafice	Jalalabad	15.21	6.7
019	Khaibar sehat	Kabul	16.23	6.4
020	Sehat	Kabul	Don't have Iodine	6.3
021	Sehat-e- watan	Kabul	Don't have Iodine	5.8
022	Bostan-e- sehat	Jalalabad	Don't have Iodine	5.9
023	Spin ghar	Jalalabad	15.12	6.2.

Table 2 explains 23 different brand codes 001, 020, 021, and 022; even though they are mentioned as iodized salt, they don't contain iodine. Codes 023, 018, 019, 010, 011, 004 and 002 have adequate iodine. 30.4% have sufficient iodine, but 82.6% don't have insufficient iodine. All salt samples have acceptable pH limits.

It is a fact that the quality of iodine in iodized salts decreases with time. For this reason, it is mandatory to include the manufacturing and expiration dates. Table 3 shows that only two samples mentioned the manufacture and expiration date. This means that 91.3% of iodized salt samples don't have manufacture and expiration date.

Table 3: Manufacture, and Expire date of samples (n=23)

Cod number	Product name	Manufactured date	Expired date
001	Madina	Not mentioned	Not mentioned
002	Sehat-e- shuma	Not mentioned	Not mentioned
003	Omid-e- Kabul	Not mentioned	Not mentioned
004	Soner	Mentioned	mentioned
005	Boston-e sehat	Not mentioned	Not mentioned
006	Omind-e- Kabul	Not mentioned	Not mentioned
007	Watan	Not mentioned	Not mentioned
008	Akhter sehat	Not mentioned	Not mentioned
009	Sehat-e-nasrat	Not mentioned	Not mentioned
010	Naveed	Not mentioned	Not mentioned
aa011	Sehat	Not mentioned	Not mentioned
012	Aetebar-e- shuma	Not mentioned	Not mentioned
013	Paris salt company	Not mentioned	Not mentioned
014	Scocdeh	Not mentioned	Not mentioned
015	Ariana-e- Zeba	Not mentioned	Not mentioned
016	Shifa	Not mentioned	Not mentioned
017	Sehat	Not mentioned	Not mentioned
018	Nafice	Not mentioned	Not mentioned
019	Khaibar sehat	Not mentioned	Not mentioned
020	Sehat	Not mentioned	Not mentioned
021	Sehat-e- watan	Not mentioned	Not mentioned
022	Bostan-e- sehat	Not mentioned	Not mentioned
023	Spin ghar	Mentioned	mentioned

Table 4 shows that salt iodine concentrations were not in the normal range. All the collected edible salt samples are different in quality and quantity of iodine and do not have the validity of the standard. Most samples are marked forgery**.**

Table4: descriptive analysis of samples (23)

Salt iodine in ppm	Frequency	Percentage
0-0 don't have Iodine	4	17.39
5-14 insufficient	9	39.1
15-30 sufficient	10	43.47
Total	23	100

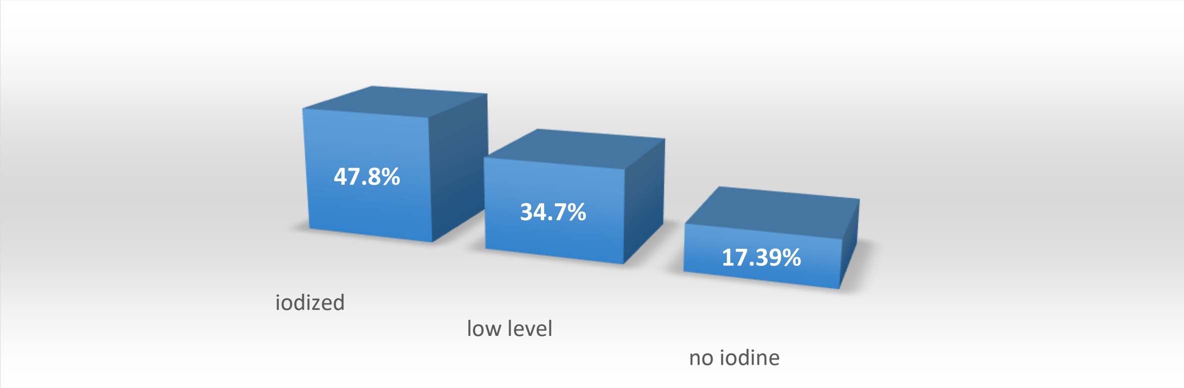

Figure 1 Percentage of iodized salts: 47.8 % of samples have Iodine at normal level, 34.7% have a low level of Iodine, and 17.39 samples don't have Iodine.

Discussion

Estimating iodine content in salt samples showed that more than 50% of the powdered samples don't have adequate iodine content (15 ppm and above). That means advice on powdered salt use does not ensure adequate iodine intake.

Preventing iodine deficiency among children constitutes a public health problem in the population. Strict salt iodization and marketing implementation in hard-to-reach locations are proposed to control iodine deficiency diseases (Halligudi, 2021).

The prevalence of goiter is disappointing in Afghanistan. The best way to prevent iodine deficiency is to prepare and distribute iodized salts in vulnerable areas. This research indicates that salt-coded 003, 006, 007, 008, 009, 013, 016 and 017 products were lower than standard in Iodine (13-30 ppm) conte. 001, 020, 021, and 022 coded despite having an iodized mark but not having Iodine. Only two samples have expired date. The ingredients were not mentioned; only five samples have the identical copy of the contents of code 002. All samples have an Iodized mark; all salts are grounded; only two samples are purified and crystalline. Not all sellers have any information about the importance of iodized salt. The use of these salts wouldn't help prevent Iodine deficiency. However, fake branded salts are unique and must be stopped. The Ministry of Health should seriously pursue this issue.

Approximately 2.5 billion people globally are thought to not consume enough iodine, with 313 million residing in Southeast Asia(Korobitsyna et al., 2020). Iodine deficiency disorders (IDD) are considered to be a significant public health concern on a global scale. Although cretinism and goiter (IDD) are said to have been recognized for over 50 years, their complete eradication remains an aspirational objective. Table 4 shows that 17% of the samples did not pass the iodine test, while 43% had an appropriate iodine level and 39% contained the lowest amount of iodine at 15 mg/kg in table salt. To get a minimum of 15 mg/kg in home dietary consumption, retail shopping malls must advise to utilize table salt with an iodine level of 20 mg/kg to 30 mg/kg.

We anticipated that the iodine concentration of the sample would differ in hot and cold temperatures since light and temperature impact the iodine's quality in salt (Fallah et al., 2020). Thus, inadequate production or an intolerable disregard for the temperature, light, and humidity levels during transportation ought to cause low iodine content (Vithanage, 2016). Numerous other variables can also lead to the loss of salt iodine, such as poor salt maintenance and storage in supermarkets, salt transportation, high temperatures, and humidity. One of the limitations of this study was its inability to evaluate the iodine content of salts that households bought and stored. Processing circumstances have a substantial impact on the iodine content of salt, otherwise making all efforts taken during manufacture and distribution to maintain adequate amounts of iodine futile. Also, when cooking, iodine concentration decreases, so all iodized salt must have sufficient iodine(Fallah et al., 2020).

Conclusion

Iodine is one of the minerals that is extremely important and necessary for health. Most of the acceptable salts had sufficient iodine concentration for consumer use. However, a tiny percentage of samples were iodine-free. Maybe they have an adequate amount of iodine at the time of production but lack awareness about the practical factors, such as moisture content, impurities, and storage conditions, affecting the amount of iodine lost from the salts.

One of the conditions for the iodization of edible salts is that they must be dry and free from impurities. Ten samples were sufficient, and nine samples were at a low level. To overcome the variance in the iodine content of salt, producers must also implement internal quality control and social understanding of salt iodization. Government assurances of the proper iodine content of salt and external monitoring will lead to improvements in hypothyroidism management. From the results obtained, it can be seen that the current situation of iodized salts is not reliable, and iodized salts cannot be used confidently to prevent diseases caused by iodine deficiency. In this regard, the Ministry of Health should take firm steps to eradicate iodine deficiency with this method.

Acknowledgment

We want to acknowledge Mr. Gull Nazir Nazime, who accompanied me in collecting samples and analyzing and writing this article. I would also like to thank the officials of the Faculty of Pharmacy for providing me with the food analysis laboratory.

Conflict of Interest

The Authors declare not conflict of interest.

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