Iodometric Titration and Spectrophotometric Method for the Determination of Iodine in Salt Samples Commercially Available in Bahir Dar, North Western Ethiopia

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Abstract
Iodine deficiency disorders (IDD) are major public health problems in many parts of the world and universal salt iodization (USI) is the best strategy to prevent and control IDD in given Community. The determinations of iodine content of the salt samples were based on standard literature procedures. The iodine content of salt samples commercially available in the super markets of Bahir Dar City measured with SP65 Uv-Vis Spectrophotometric method were found to be in the ranges of 5.634±0.312 to 60.098±0.132 ppm for fine salt and 5.288±0.086 to 8.321±0.756 ppm for coarse salt and with Iodometric titration ranging from ND (not detected) to 60.477±2.122 ppm in fine salt and none in coarse salt. Of all the salt samples collected from Bahir Dar, 61.54 % (n = 8) were insufficiently iodated; 23.08 % (n = 3) were adequately iodated and 15.38 % (n = 2) were over-iodated. The quality of iodized salt in Bahir Dar city is not uniform and the universal salt iodization program in Ethiopia needs strict quality assurance measures at the stages of production, storage, import and retail levels for a successful and sustainable prevention of IDD.
Keywords: iodine; iodized salt; Iodometric titration; Uv-Vis Spectrophotometry

1. INTRODUCTION

Iodine is an essential micronutrient in animals and humans, necessary for the production of thyroid hormones and for the proper functioning of the thyroid gland [1]. Iodine constitutes about 0.00004% of the total human body weight [2] and is used in a single metabolic pathway; it is a constituent of the thyroid hormones, thyroxine (T_4) and tri-iodothyronine (T_3) [3]. Thyroid hormones are important for the regulation of the body metabolism. The physiological actions of thyroid hormones can be categorized as 1) growth and development and 2) control of metabolic processes in the body. The human body cannot synthesize iodine and it cannot be stored for long periods; thus it is necessary to obtain it from different sources, with food being the most important and tiny amounts are needed regularly. Dietary intake is the primary source of iodine intake for the general population. Marine sea foods typically contain the highest amount of iodine (range 160–3200 μg/kg; mean 660 μg/kg), with shellfish having a mean iodine concentration of 0.798–1.6 mg/kg. Kelp and other seaweeds (1–2 mg/kg) and sea salt (up to 1.4 mg/kg) provide other abundant sources of iodine. In industrialized countries, the most important sources of iodides are dairy products, such as whole cow's milk (mean 27–47 μg/kg), eggs (mean 93 μg/kg), and grain and cereal products (mean 47 μg/kg, depending on the soil); other food sources are freshwater fish (mean 30 μg/kg); poultry and meat (mean 50 μg/kg); fruits (mean 18 μg/kg), legumes (mean 30 μg/kg), and non-legume vegetables (mean 29μg/kg) [2, 4]. Iodine deficiency disorders are a group of diseases that results from a relative lack of iodine in the diet. They are found throughout the world, in countries at all stages of development, although they are commoner in remote and deprived communities. The disorders include goiter, cretinism, reduced IQ, miscarriages, birth defects and deaths around the time of birth [4] and severe mental retardation, deaf- mutism [5] and partial paralysis, and can adversely affect the entire human body including its muscle, heart, liver, kidneys and the developing brain. IDD can also cause growth retardation, reproductive failure, child hood mortality, physical sluggishness and other defects in the development of the nervous system. Ethiopia is among the high risk iodine-deficient countries in the East African region where iodine deficiency is prominent [6]. IDD has been recognized as public health problem in Ethiopia for more than four decades since 1950. In Ethiopia, one out of every 1000 is a cretin and about 50,000 prenatal deaths are occurring annually due to IDD, 26% of the total populations have goiter and 62% of population is at risk of IDD according to national survey made by previous Ethiopian nutritional institute. In some pocket areas of the country, the prevalence of goiter is found to be 50% - 95% (WHO considers that if the goiter rate is above 5% in the population it is public health problem). From the various surveys conducted in many parts of Ethiopia, IDD has become one of the biggest public health concerns [7]. Universal salt iodization (USI), the primary strategy to prevent IDD, was adopted in 1993. Since then, more than 90 million newborns are protected each year from learning disabilities caused by IDD [8]. In

1994, a special section of the WHO and UNICEF joint committee on health policy recommended USI as a safe, cost effective and sustainable strategy to ensure sufficient intake of iodine by all individuals. In nearly all countries where iodine deficiency occurs, it is now well recognized that the most effective way to achieve the virtual elimination of IDD is through USI [9]. In 2011, it was estimated that about 66 million persons in Ethiopia were unprotected from iodine deficiency as only 15 % of households had access to adequately iodized salt. Ethiopia had the lowest coverage of adequately iodized salt amongst countries in Sub-Saharan Africa during this period [10]. Food, medication, and supplements are sources of iodine. In general, consumption of iodine that exceeds the recommended dosage by as much as ten times is well tolerated by most people. Excessive intake of iodine may cause over-stimulation of the thyroid gland, which produce excess hormone and cause hyperthyroidism. However, some people respond adversely to levels close to the recommended intake [12]. As iodine deficiency impairs thyroid function, iodine excess including over correction of a previous state of iodine deficiency can also impair thyroid function. Both high and low iodine intakes are associated with an increased risk of thyroid disorders [13].

2. MATERIALS AND METHODS

The iodine concentrations in salt samples commercially available in Bahir Dar city were determined with the help of standard literature procedures using Iodometric titration and Spectrophotometric methods. Eight fine and five coarse crystal salt samples which are available in supermarkets of Bahir Dar City from different countries (inland and foreign) were purchased and the salt samples were kept unopened in the sealed plastic bags in the dark until analyzed. The anonymity of coarse salt was maintained by use of codes and fine salt by their name. The aim of this study was to determine iodine content of the salt and also give baseline information for controlling and monitoring the iodine content of salt commercially available for human consumptions.

3. RESULTS AND DISCUSSIONS

Evaluation of Salt Samples in Bahir Dar

Table 1: Average iodine content estimated in iodized salt available in Bahir Dar City from different countries by Uv-Vis Spectrophotometric and Iodometric Titration methods. Average results in mg/kg (ppm) from triplicate determinations, 95% confidence level are shown.

Salt Sample Type	**Sample name or code**	**Manufactured in**	**Labeled iodine value**	**Uv-Vis Spectrophoto metric mean ± SD (ppm)**	**Iodometric Titration Mean ± SD (ppm)**
Fine Crystal Salt	Mulu iodized table salt	Ethiopia	NG	51.113±0.278	52.696±1.621
	Iodized Lo salt	East Kilbride, cotland	NG	29.678±0.132	31.830±1.733
	Ermon table salt	Ethiopia	NG	27.969±0.590	28.293±0.613
	Risa iodized salt	Saudi Arabia	70-100 pm	13.753±0.132	14.854±1.061
	Hayat iodized table salt	Ethiopia	NG	7.079±0.050	ND
	Iodized salt Zad natural & pure	Saudi Arabia	70-100 pm	37.821±0.877	38.903±1.621
	American garden double refined iodized salt	New York, U SA	60 µg	5.634±0.312	ND
	woff iodized table salt	Ethiopia	NG	60.098±0.132	60.477±2.122
Coarse Crystal Salt	S1	Ethiopia	NG	5.750±0.477	ND
	S2	Ethiopia	NG	5.288±0.086	ND
	S3	Ethiopia	NG	7.108±0.150	ND
	S4	Ethiopia	NG	6.645±0.557	ND
	S5	Ethiopia	NG	8.321±0.756	ND

NG: Not given
ND: None Detected

As shown from the **Table 1**, the iodine contents of different commercially available salts in Bahir Dar City from different countries were estimated using Uv-Vis Spectrophotometric method and Iodometric titration. The results showed that, the iodine content of fine crystal salts measured by Uv-Vis Spectrophotometric method was found to be in the ranges of 5.634±0.312 to 60.098±0.132 ppm and iodine in the coarse from 14.854±1.061 to 60.477±2.122 ppm by iodometric titration. Salt samples commercially available for human consumption in the study area indicates non- homogeneous distribution of iodine in the salt, varying from fine to coarse crystal salt. Among fine salt samples measured by spectrophotometric method, the largest iodine content was found in refined and iodized woff table salt (60.098±0.132 ppm) and the minimum spread was found in Hayat iodized table salt (7.079±0.050 ppm) and for coarse crystal salts measured by Uv-Vis Spectrophotometric method the largest iodine content was found in S_5 (8.321±0.756 ppm) and the minimum spread was found in S_2 (5.288±0.086 ppm). All coarse salt samples were insufficiently iodated. Moreover, the iodine contents labeled on Risa iodized salt and iodized salt Zad natural and pure 70- 100 ppm was not confirmed during analysis. This difference in iodine content in salt samples commercially available for human consumption in the study area is may due to variability in the amount of iodine added during iodization, the form in which iodine is present, poor mixing resulting in uneven distribution within the bags (batches) produced, instability of iodine in salt, long production date and storage, exposure to high temperature, impurity, moisture and transportation from production to consumers. The quality and standard authority of Ethiopia, has set the iodine level to be 60-80 ppm as potassium iodate, after making allowance for losses of iodine during storage and distribution. [14, 15]

Table2: Iodine content of fine (n = 8) and coarse (n = 5) salt samples in total (n = 13), 2015 Bahir Dar

Iodine content	**Uv-Vis spectrophotometric method**		**Iodometric titration method**	
	Number of samples	**Proportion %)**	**Number of samples**	**Proportion (%)**
Non-iodated (< 5 ppm)	0	0	7	53.85
Insufficiently iodated (5-14 ppm)	8	61.54	1	7.69
Adequately iodated (15 – 45 ppm)	3	23.08	3	23.08
Over-iodated (> 45 ppm)	2	15.38	2	15.38

As seen from **Table** 2, the iodine content of salt samples measured with Uv-Vis spectrophotometric method shows 61.54 % (n = 8) were insufficiently iodated, 23.08 % (n = 3) were adequately iodated and 15.38 % (n = 2) were over-iodated and with iodometric titration method 7.69 % (n =1) was insufficiently iodated, 23.08 % (n =3) were adequately iodated , 15.38 % (n =2) were over-iodated according to WHO recommended level of iodization where 0 up to less than 5 ppm non- iodated, 5- 14 ppm insufficiently iodated, 15- 45 ppm adequately iodated and greater than 45 ppm over iodated. Iodization level 60- 80 ppm is adequate level for human consumption according to legestilations of salt iodization set in Ethiopia and none of the salt commercially available in Bahir Dar City purchased in the supermarkets and analyzed with both iodometric titration and Uv- Vis spectrophotometric method was over iodated[15].

4. CONCLUSIONS AND RECOMMENDATION

Iodine is an indispensable microelement to human and is required in small quantity for the well being of individuals, and to prevent IDD. Salt iodization is by far the most important population-based intervention for IDD control and has been shown to be effective in alleviating IDD assuming iodine concentrations in the salt are at appropriate levels at the time of consumption. Controlling the level of iodization at the production stage, port of entry and retail level with suitable technique is also part of iodization program to prevent IDD. The present work demonstrated successful application of Uv-Vis Spectrophotometric method than Iodometric titration for the determination of iodine in iodized salts. Commercially available coarse iodized salts and fine iodized salts like Risa iodized salt and American garden double refined iodized salts do not comply with WHO recommended level (20-40 ppm) of iodine and the leveled iodine contents in Risa and Zad natural and pure iodized salts (70-100 ppm) was not confirmed by analysis. Among salt samples (n = 8, fine crystal salt and n = 5, coarse crystal salt) evaluated for their iodine content found in the study area, most of them are insufficiently iodated (n = 8, 61.54%), some are adequately iodated (n = 3, 23.08%) and some are over iodated (n= 2, 15.38%).This evidences lack of quality assurance and control in the manufacturing of iodized salts. Therefore, universal salt iodization program in Ethiopia needs strict quality assurance measures at the stages of production, storage, import and retail levels for a successful and sustainable prevention of IDD.

Since the salts available for human conception coming from inland and foreign countries are not iodized at the recommended level set by the government of Ethiopia, the following are recommended.

- Establishing different laboratories and Networking them both at national and regional or sub regional level for USI for progress towards controlling and elimination of IDD.
- Quality control, program monitoring and evaluation system of salt iodization needs to be in place along the chain to ensure the adequate supply of iodine

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