

**COLLEGE OF NATURALSCIENCE  
SCHOOL OF GRADUATE STUDIES  
DEPARTMENT OF CHEMISTRY**



**EVALUATION OF IODINE CONTENT IN COMMERCIALY  
AVAILABLE TABLE SALTS AND KNOWLEDGE, ATTITUDE AND  
PRACTICE OF CONSUMERS AND RETAILERS IN SELECTED AREA  
OF JIMMA TOWN, SOUTH WEST ETHIOPIA**

**DECEMBER, 2023  
JIMMA, ETHIOPIA**

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SELECTED AREA OF JIMMA TOWN, SOUTH WEST ETHIOPIA**

**BY**

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**JIMMA UNIVERSITY**  
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**MSc THESIS APPROVAL SHEET**

We, the undersigned, member of the Board of Examiners of the final open defense by **REMLA ABA TEMAM** have read and evaluated his/her thesis entitled “**Evaluation of Iodine Content in Commercially Available Table Salts and Assessment of Knowledge, Attitude and Practice of Retailers and Consumers in Jimma Town, South West Ethiopia**” and examined the candidate. This is therefore to certify that the thesis has been accepted in partial fulfillment of the requirements for the degree Master of Science in **APPLIED CHEMISTRY (FOOD SAFETY AND QUALITY)**.

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## List of abbreviations and acronyms

DIT	Di-iodotyrosine
EFMH	Ethiopian Federal Ministry of Health
ICCIDD	International Council for Control of Iodine Deficiency Disorder
ID	Iodine Disorder
IDD	Iodine Deficiency Disorder
IIH	Iodine Induced Hyperthyroidism
IQ	Intelligence quotient
KAP	Knowledge, attitude and practice
MIT	Mono-iodotyrosine
ppm	Parts per million
QSAE	Quality and Standard Authority of Ethiopia
RDA	Recommended Dietary Allowances
RTK	Rapid test kit
T3	Tri-iodothyronine
T4	Tetra-iodothyronine or thyroxin
TSH	Thyroid Stimulating Hormone
UNICEF	United Nation International Children's Emergency Fund
USI	Universal Salt Iodization
WHO	World Health Organization

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## **Abstract**

Iodine is a crucial trace element for human nutrition that is very important for the secretion of thyroid hormones. Iodine deficiency disorders are caused by inadequate iodine intake. Iodination of table salt is one of the universally used methods to eliminate iodine deficiency disorders and thyroid-related diseases. Iodine content levels in table salt can vary during iodination for a variety of reasons. The main aim of this study is to determine iodine content in commercially available table salts and assess of knowledge, attitudes, and practices of retailers and consumers in Jimma town, South West Ethiopia. The iodine content of different salt samples was determined by rapid test kit and iodometric titration and semi-structured questionnaire was used for the assessment of knowledge, attitude, and practice of retailers and consumers. Statistical analyses were analyzed using the software, Statistical Package for the Social Science version 26 and results were expressed as mean  $\pm$  standard deviation. The content of iodine in the studied salt samples determined by iodometric titration was found between  $35.37 \pm 0.25$  mg/kg to  $82.05 \pm 0.67$  mg/kg. The highest iodine content was obtained in Koketi ( $82.05 \pm 0.67$  mg/kg) and the least iodine content was found in Afar salt ( $35.37 \pm 0.25$  mg/kg). Rapid test kit analysis showed that the iodine content in Koket, Liq, and Jimmiti is greater than 15 mg/kg, while the iodine content in Jimma, NM iodized salt, Abay, and Afar is less than 15 mg/kg. Shaga, Barta, and Gold showed no iodine content. The World Health Organization recommends that iodine be added to salt as a public health measure to prevent iodine deficiency. The recommended iodine content in iodized salt is at least 15 mg/kg but not more than 40 mg/kg. Regarding iodized salt usage, storage, and practice, a total of 90 participants (60 consumers and 30 retailers) were assessed for knowledge, attitude, and practice, the majority of consumers and retailers responded that they do not have awareness about the health benefits of iodized salt. According to the result, most of the people selected from the study area had poor Knowledge, Attitude, and Practice.

**Keywords:** - *Iodine, Iodine deficiency disorders, Iodometric titration, Rapid test kit, knowledge, attitude and practice*

# 1. INTRODUCTION

## 1.1. Background

Iodine is a micronutrient required for thyroid hormone synthesis. Thyroid hormones play a vital role in regulating a basal metabolic rate, general growth and development [1, 2]. The human body cannot synthesize iodine and, it cannot be stored for a long period. Therefore, it is necessary to obtain it from different sources of food and, small amounts are needed regularly [3]. Iodine is widely but unevenly distributed in the earth's environment. Leaching, flooding and erosion in many regions deplete surface soils of iodine [4]. The native iodine content of most foods is low, while foods of marine origin have a higher content. Despite this, about 90%, of dietary iodine is derived from foods and 10% from drinking water. Dietary intake is the primary source of iodine like Seafood, dairy products and plants grown in iodine-rich soils [5].

Iodine deficiency disorder (IDD) is one of the public health problems that confront 118 countries worldwide, and approximately 1.5 billion people are at risk of preventable IDD [6]. Another study showed that more than two billion people, 28% in the world and most of them in developing countries (39% in Africa) suffer from an inadequate intake of iodine [7]. The deficiency results in problems such as abortions, stillbirths, congenital abnormalities, cretinism, goiter, impaired mental function, squinting and mutism [8]. It is reported that at least 350 million Africans are at risk of iodine deficiency.

According to a national survey made by the Ethiopian nutrition institute, one out of each 1000 is cretin, and about 50,000 perinatal deaths are occurring annually due to IDDs [9]. In Ethiopia, it is expected that 100,000 children born each year are at risk of intellectual impairment because of iodine deficiency. Approximately 15,600 (13%) of these babies are severely impaired and are unable to develop properly, which results in an average of 22 million dollars in losses in productivity each year in Ethiopia. Most of these affected children are also held back by reduced intelligence and mental dullness which are enormous negative educational implications of iodine deficiency [10].

Excessive iodine intake from food and water can also have adverse chronic health effects such as Iodine iodine-induced hyperthyroidism (IIH), thyroiditis, goiter, thyroid papillary

cancer and thyrotoxicosis [11]. Long term too much iodine intake increases the activity of Thyroid Stimulating Hormone (TSH) and reduces thyroid hormone production, through loss of the "escape" phenomenon after the Wolff-Chaikoff effect (inhibits organification in the thyroid gland, the formation of thyroid hormones inside the thyroid follicle and the release of thyroid hormones into the bloodstream) resulting in low thyroid hormone levels or hypothyroidism in fetuses and newborns [12]. Chronic exposure to iodine in several milligrams per day or 1100 µg/day can disrupt thyroid function [13]. Similarly, a clear relationship between excessive iodine intake and distribution of differentiated thyroid cancer and the risk of IHH after correction of iodine deficiency has been identified [14].

Universal Salt Iodization (USI) is the most effective way of preventing IDD. Salt is an exceptional carrier for iodine, as it is consumed at relatively constant, well-defined levels by all individuals within a society, independently of economic status [15]. According to the World Health Organization (WHO), the recommended iodine intake for adults should be 150 µg per day and recommended iodine intake for pregnant women is 200 to 250 µg per day. Hence to provide a 150 µg daily requirement of iodine for each person, the salt iodine concentration at the point of production should be 20–40 mg per 1 kg of iodized salt [16]. That recommended level was estimated by WHO, under the assumptions of 20% loss of iodine from production site to household, 20% loss when cooking and 10 g of salt as average salt intake per capita [17]. In the direction to prevent IDD, salt iodine testing is a vital process that is an indicator for monitoring progress towards USI.

After making allowance for losses of iodine during storage and distribution, the quality and standard authority of Ethiopia has set the iodine level to be between 36 - 48 mg/kg. The average consumption of salt per person per day is 10g and the recommended daily requirement of iodine is 150µg per adult to prevent IDD. So, monitoring salt iodization is useful and the first step in following progress toward meeting the goal of IDD elimination or prevention. Consumption of iodized salt is the best way to eliminate iodine deficiency disorders [18]. The content of iodine added as iodate or iodide to the salt can be affected by heat, light, time and other environmental factors. One study conducted in Palestine showed that to determine the content of iodine out of 99 salt samples collected from Palestine consumers, it was found that 23-28% of samples have lost iodine content by 61-80% and 9% have lost up to 100%. And about 43.5% of samples fit the Palestinian standards institute

recommendation (35-55ppm) while 58% fit United Nations International Children's Emergency Fund (UNICEF) recommendation (15%) [18]. Another study conducted in Bangladesh showed that Out of ten brand samples, only one sample had poor content of iodine. But that might be also due to long exposure to moisture or heat while working in the laboratory [19, 20]. However, there is a gap in the assessment of iodine content in commercially available table salts and the knowledge, Attitude and Practice (KAP) of consumers and retailers in Jimma town, southwest Ethiopia. In this area, research was not yet well conducted. In Jimma town; there are different salts from inland and foreign countries that are commercially available for human consumption. Therefore, it is important to study the iodine content present in table salt and KAP assessment to generate information about it.

In this study, the iodine content of different salt samples was determined by iodometric titration and rapid test kit and semi-structured questionnaire was used for the assessment of knowledge, attitude, and practice of consumers and retailers. The content of iodine determined by iodometric titration was found between 0 mg/kg to  $82.05 \pm 0.67$  mg/kg while RTK result was showed 3 salt sample  $< 0$  ppm, 4 salt sample  $< 15$  ppm and 3 salt sample  $> 15$  ppm. When we compared the result with WHO standard and QSAE from the total of ten salt samples, 30% were non iodized, 30% were adequately iodized and 40% of salt brands collected from selected areas contained over amount of iodine ( $>40$ ppm). The estimation of the salt iodine by using RTK is based on the reaction between starch and iodine to form a starch-iodine complex.

Also, Regarding iodized salt usage, storage, and practice, a total of 90 participants (60 consumers and 30 retailers) were assessed for knowledge, attitude, and practice, the majority of consumers and retailers responded that they do not have awareness about the health benefits of iodized salt. According to the result, most of the people selected from the study area had poor Knowledge, Attitude, and Practice. So the finding of this study will give the iodine concentration of the different table salt brands and the scope of the KAP of the consumers and traders in Jimma town selected areas.

## **1.2. Statement of the problem**

In many areas of the world, the soil does not contain an adequate amount of iodine. Especially, in mountainous areas, the soil has an inadequate amount of iodine which leads to

the prevalence of IDD. Central Africa, Central Asia and much of Europe also have iodine-depleted soil [21]. Iodine is found naturally in topsoil unevenly distributed and this loss is due to deforestation, erosion, and flooding including in some parts of Ethiopia which results in dietary iodine deficiency mainly marine water bodies (ocean and sea water) contain higher concentrations of iodine and used as the main source for many countries. For Jimma town, some agricultural commodities come from different regions of Ethiopia including Oromiya, south nation nationality, Gambella and Amhara region. Some of these areas are mountainous, and there are high flooding and erosion. Different studies conducted in the Jimma area and Jimma town showed cases of goiter, impaired mental function, poor school performance and growth retardation [22]. However, in Jimma town, there is not yet research on the concentration of iodine content in iodized salt that is commercially available and KAP assessment of the communities. Therefore, this triggers the researcher to assess the iodine content of table salt and the knowledge, attitude and practice of consumers and trader's in Jimma town. The finding of this study was answering the following questions.

- ❖ What is the iodine concentration of the different table salt brands in Jimma town?
- ❖ What is the extent of the KAP of the consumers and traders?

### **1.3. Significance of the study**

In developing countries, salt production and the quality of available iodized salt may be poor. Salt may be correctly or incorrectly iodized it may deteriorate due to excessive exposure to moisture, light or heat. All these factors should be taken carefully into account, particularly when establishing the initial level of iodine in salt at the production level, shop and consumption level mainly in developing countries many people are at risk of IDD. These IDDs include goiter, cretinism, stillbirth and abortion [21]. So, these disorders can be successfully prevented by the consumption of an adequate amount of iodine in the diet.

USI is a recommended intervention for preventing and correcting iodine deficiency. The prevention can result in improved quality of life, productivity, and education of children and adults [23]. Generally, the study has the following significance:-

- ❖ The finding of this study will give baseline information for researchers, academicians and concerned bodies to control and monitor the iodine content of salts available for human consumption.
- ❖ The study can be used to ensure the safety of the iodine content of salt products for human consumption as well as to safeguard the health of the consumers.
- ❖ Used to increase the KAP of consumers and retailers.

## **1.4. Objective**

### **1.4.1. General objective**

- ❖ To evaluate iodine content in commercially available table salts and Knowledge, Attitude and Practice of Retailers and Consumers in Jimma Town, South West Ethiopia.

### **1.4.2. Specific objectives**

- ❖ To determine iodine content in table salts of different brands.
- ❖ To compare the level of iodine in different table salt brands with WHO and Ethiopian standards.
- ❖ To assess the KAP of a consumer and Retailer.

## **2. LITERATURE REVIEW**

### **2.1. Iodine**

Iodine is an important micronutrient required for structural development and optimal functional activity of the thyroid gland and central nervous system. About 15 - 20 mg of iodine is found in total body of healthy people; 70 - 80% present in the thyroid. Globally iodine deficiency is one of the most prevalent micronutrient deficiencies and is the main cause of potentially preventable cognitive disability in childhood. Globally, IDD results in more than 18 million babies being born mentally impaired in each year. It obstructs brain development during infancy and childhood [24]. In Ethiopia, it is estimated that over 35 million people are at risk of IDD and over 20 million people suffer from goiters (TGR of 26%). The total percentage of goiter among school children varies across regions (39.9% nationally). Also, endemics have been described in many areas caused by Goitrogens in drinking water that may contain various chemical compounds interfering with thyroid hormone synthesis. These hormones are necessary for protein synthesis and process of early growth and development of most organs [25]. When community's awareness towards associating factors is high, the solution to iodine deficiency disorder is relatively simple and inexpensive. Addition of iodine to salt provides protection from brain damage due to iodine deficiency disorder [26].

Common sources of iodine are water and diets that are dependent on levels of soil iodine. Iodine is widely but irregularly distributed in the earth's environment. Leaching, flooding and erosion in many regions reduce surface soils of iodine. Because The natural iodine content of most foods is low, while foods from marine origin have higher content, but difficult to get easily [27, 16]. Iodine cannot synthesize by human body and it cannot be stored for long periods; thus, it is necessary to get it from different sources, with food being the most important and small amounts are needed regularly. Iodine forms important content food group fish, marine, eggs, shellfish, dairy product (yoghurt, milk and cheese) ,vegetable and fruits (avocado, apples tomato nut and banana) and cereals (brown and white bread, biscuit, corn bread and cake) Dietary intake is the primary source of iodine. Sea foods, dairy products and plants grown in iodine rich soils are common source of iodine [28].

**Table 1. Source of iodine**

Source of iodine	Amount of iodine
Kelp and other weeds	1-2 mg/kg
Shellfish	0.79-1.6 mg/kg
Sea salt	1.4 µg/kg
Egg	93µg/kg
Poultry and meat	50 µg/kg
Grain and cereals	47 µg/kg
Fresh water fish	30µg/kg

**Source:** (WHO 2007; Duressaet *al.*, 2014; Bienertová-Vaškůet *al.*, 2018)

The main source of iodine is iodized salt in many countries; because it is consumed by every person and the consumption is regular throughout the years. But commonly in developing countries knowledge, attitude and practice on iodized salt consumption is poor. [28]. Different amounts of iodine intake are recommended for different group of populations (infants, children, adults, pregnant and lactating women) [17]. As mentioned table below.

**Table 2. Recommended daily intake by WHO, UNICEF and ICCIDD**

Age group or population group	Recommended daily intake in µg/day
Preschool children (0-5 years)	90
School children ( 6-12 years)	120
Adults ( >12years)	150
Lactating women	250
Pregnant women 250	250

**Source:** (Maheswariet *al.*, 2019; Agbozoet *al.*, 2017; WHO, 2007)

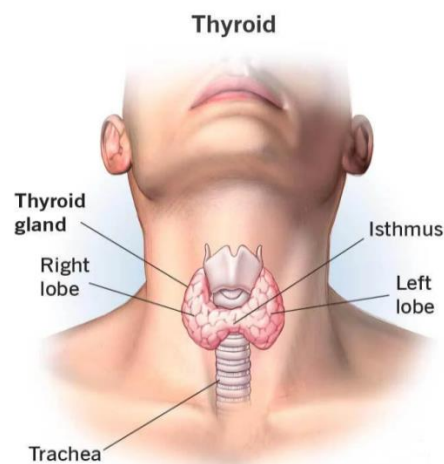
## 2.2. Thyroid gland

The thyroid is a small, butterfly-shaped gland located at the front of the neck under the skin. It's a part of the endocrine system and controls many of our body's important functions by producing and secreting certain hormones. The thyroid's main job is to control the

metabolic rate, which is the process of how our body transforms the food we consume into energy. There are hormones produced and released by the thyroid gland [29, 2].

- ❖ Thyroxine (T4): This is the principal hormone that the thyroid makes and releases. This hormone is mostly produced by the thyroid, yet it has little impact on our metabolism. Once the thyroid has released T4 into our bloodstream, it can then undergo a process known as deiodination to change to T3.
- ❖ Tri iodothyronine (T3): T3 is produced by thyroid in smaller levels than T4, but it has a far greater impact on metabolism.
- ❖ Reverse tri iodothyronine (RT3): Your thyroid makes very small amounts of RT3, which reverses the effects of T3.
- ❖ Calcitonin: This hormone helps regulate the amount of calcium in your blood.

The thyroid gland requires iodine to produce thyroid hormones. Iodine is captured by the thyroid gland, which turns it into thyroid hormones. The amount of hormones our thyroid produces and releases can change if iodine is deficient or excess [28].



**Figure 1. Thyroid gland** (<https://www.gettyimages.com/photos /thyroid gland>)

Thyroid hormones are important for the normal development of the central nervous system in infants, skeletal growth and maturation in children and normal functioning of multiple organ systems in adults. Thyroid hormone stimulates metabolism in different tissues. It increases energy production and oxygen consumption in most tissues, regulates carbohydrate metabolism and stimulates the synthesis of proteins and lipolysis [1, 29].

### **2.3. Iodine deficiency disorder (IDD)**

Iodine deficiency is one of the most prevalent micronutrient deficiencies and is the main cause of potentially preventable cognitive disability in childhood. Globally, IDD results in more than 18 million babies being born mentally impaired each year. It obstructs brain development during infancy and childhood WHO Globally estimated that two billion people (35.2%) of the world population are at risk of IDD and suffer from insufficient iodine intake. As a result, every year 22 million children are at risk of impaired intellectual function and lower school performance globally [30,,21]. Due to insufficient iodine in foods, and drinks and aggravating factors that affect the bioavailability of iodine in the body, millions of people mainly in developing countries are affected by IDD. It is reported that at least 350 million Africans are at risk of iodine deficiency. In Ethiopia estimated that over 35 million people are at risk of IDD and over 20 million people suffer from goiter [31].

In Ethiopia, ID has remained a public health problem among school children for many decades and the prevalence rate has reached 59.1 % in Senbo District, southwest Ethiopia. Also, it causes 37.3 cretins, 33.4 miscarriages, and 47.5 stillbirths and neonatal deaths per 1000 live birth [32, 6]

According to a national survey made by the Ethiopian nutrition institute, one out of every 1000 is cretin, and about 50,000 perinatal deaths are occurring annually due to IDDs [33, 6]. The prevalence of IDD varies across regions and people living in mountainous areas. Also, it may occur in all stages of the population. IDDs include goiter, cretinism, miscarriage, severe mental retardation, and deaf-mutism [34, 10].And the like that can adversely affect the entire human body such as muscles, heart, liver, kidneys and brain [35].

**Table 3. Iodine disorders by age group**

<b>Age group</b>	<b>Health consequences of iodine deficiency</b>
All ages	Goiter Increased susceptibility of the thyroid gland to nuclear radiation In severe iodine deficiency, hypothyroidism
Fetus	Abortion, stillbirth, congenital anomalies and perinatal mortality
Neonate	Infant mortality, Endemic cretinism
Child and adolescent	Impaired mental function, Delayed physical development
Adults	Impaired mental function, reduced work productivity, Toxic nodular goiter, hyperthyroidism

**Source:**(Zimmermann and Boelaert,2015)

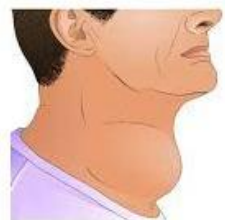
## 2.4. Hypothyroidism

When the thyroid gland doesn't produce enough thyroid hormone, hypothyroidism develops. Another name for this illness is underactive thyroid. Early on, hypothyroidism may not show any symptoms at all. If hypothyroidism is left untreated, it might eventually result in additional health issues like high cholesterol and cardiac issues. Manifestation may occur at different age groups rarely recognized in the newborn, since the signs and symptoms are usually not sufficiently developed and difficult to diagnose. It has various manifestations, particularly in children. Prevalence of hypothyroidism increases with age and disorder is common in females than in males [36, 11]. Hypothyroidism is detected by low levels of thyroid hormone in the blood resulting in lethargy, depression, and dry skin, loss of hair, weight gain, cold intolerance and constipation. In very young children, in addition to the above symptoms, it results in mental and growth retardation [37, 11].

## 2.5. Goiter

A goiter may develop from an abnormal cell proliferation that causes one or more lumps (nodules) in the thyroid or it may be an overall enlargement of the thyroid. Thyroid hormone levels may rise or fall about a goiter. Iodine deficiency in the diet is the leading cause of goiters in the world [38].

The primary sign of goiter is swelling of the thyroid gland; other possible symptoms are a tight feeling in the throat, coughing, and difficulty in swallowing and breathing [38]. It is estimated that over 35 million people are at risk of IDD and over 20 million people suffer from a total goiter rate (26%) [31]. Nationally, the total percentage of goiter among school-children is 39.9%, which is the highest one among any other age group while 36% is among biological mothers of school children [39]



**Figure 2. Image of Goiter.** Source: (<https://www.gettyimages.com/photos/goiter>)

## 2.6. Cretinism

Iodine deficiency in serious periods of brain development and growth causes severe and permanent growth and cognitive impairment (cretinism) as thyroid hormones are required for myelination, neuronal formation and differentiation during the first trimester of gestation, and subsequently for brain growth and differentiation [40, 34].

Cretinism is the most severe consequence of iodine deficiency occurring during fetal and neonatal life. It is the result of iodine deficiency during pregnancy, which adversely affects fetal thyroid function [41]. For normal fetal brain development, a normal concentration of thyroid hormone is very important. If there is iodine deficiency during the first trimester, the fetal brain may get damaged and leading to irreversible mental retardation, deaf-mutism, short stature and retarded development of the musculoskeletal system [42].



**Figure 3. Image of cretinism**

**Source:** (<https://www.gettyimages.com/photos/cretinism>)

## 2.7. Causes of IDD

The prevalence of IDD is high in developing countries; it is more closely linked to populations having low income, and rural populations, who lack access to iodized food. It is common in Ethiopia because of high plateau areas. Iodine is naturally found in topsoil and the topsoil has been lost due to erosion and flooding, thus crops lack iodine, resulting in dietary iodine deficiency [43, 44]. Consequently, lack of availability of iodine from the soil linked to low dietary intake of iodine is the main cause of IDD. When the amount of iodine in food is lower than the body's needs, IDD happens and consequently the thyroid gland will not be able to synthesize an adequate amount of thyroid hormone. In addition to depletion of soil iodine content, poor economic status, poor knowledge about iodized salt, adding salt

during or at the beginning of food preparation and poor knowledge about consequences of iodine deficiency are significantly associated with iodine deficiency [42].

Goitrogen is another risk for iodine deficiency. It is a substance that interferes with iodine utilization. Goitrogen is metabolized to thiocyanate and blocks thyroidal uptake of iodine. Some species of millet and cruciferous vegetables contain goitrogen. In addition, some plants such as cassava contain thiocyanate that inhibits thyroid iodide transport [45].

## **2.8. Prevention and control of IDD**

When iodine is lost by erosion from the soil, the crops that grow in that soil lack iodine. As a result, crops do not provide sufficient dietary iodine to the population. When there is a lack of iodine in the earth's crust, iodine deficiency happens [46]. Because by using different techniques soil erosion should be prevented. Intensive care of iodine content in the salt at the production and import sites before salt enters into local markets to guarantee correct and safe iodine levels is reaching consumers and taking legal action against noncompliant salt producers or traders is the main thing to prevent and control IDD [24]. The recommended strategy for IDD control is based on correcting the deficiency by increasing iodine intake through supplementation or food fortification because IDDs cannot be eliminated by simply changing dietary habits or by eating specific kinds of foods [47].

## **2.9. Salt iodization**

USI involves the iodization of all human and livestock salt, including salt used in the food industry. Adequate iodization of all salt will deliver iodine in the required quantities to the population on a continuous and self-sustaining basis. The additional cost of iodine fortification in the process of salt production should eventually be borne by the consumer but is negligible. This will greatly assist sustainability [48, 49].

There is no universal specification for the level of iodine to be added to salt to achieve the recommended intake of iodine. The appropriate level of salt iodization depends on the individual consumption of salt, the degree of iodine deficiency in the area and the loss of iodine from producer to consumer. According to WHO, UNICEF and ICCIDD, the salt has to be fortified with 20-40mg of iodine per kilogram of salt at the production site and the household level it should have 15-40ppm of iodine [50]. The USI program was launched in

1995/1996 in Ethiopia. In June 2004 the National Guideline for Control and Prevention of Micronutrient Deficiency formulated by the Ethiopian Federal Ministry of Health (EFMH) states that in Ethiopia, the iodine content of salt to be 80 - 100 ppm as KIO<sub>3</sub> at the port of entry. Quality and Standard Authority of Ethiopia (QSAE) has set the iodine level to be 60 - 80 ppm as KIO<sub>3</sub> or 36 - 48 ppm as iodine after making allowance for losses of iodine during storage and distribution [51].

#### **2.10. The risk of excess iodine intake**

Too much intake of iodine may cause overstimulation of the thyroid gland, which produces excess hormone and cause hyperthyroidism. As iodine deficiency impairs thyroid function, iodine excess including over correction of previous state of iodine deficiency can also damage thyroid function. Both high and low iodine intakes are associated with an increased risk of thyroid disorders [51, 27].

#### **2.11. Methods for determining iodine Content in the Salt**

Recently, several methods for testing the iodine content of salt have been reported ranging from qualitative spot tests by rapid test kit to the more quantitative methods such as iodometric titration, spectrophotometric method and like [52]. In this study, a rapid test kit and iodometric method will be chosen because of the reasons discussed below.

#### **2.12. Iodometric Titration**

Titration is the most frequently used method to determine quantities of iodine in salt because of its accuracy, relative easy to use and incurs low cost. This method is recommended at various levels of a distribution system. Internal and external quality control measures are necessary once a method has been established. The titration method for KIO<sub>3</sub> was introduced in 1979. However, the titration method is not recommended for routine national monitoring purposes because it's a time-consuming process [53].

In the titration method, the iodine content of salt can be determined by liberating iodine from a salt sample and then by the titration of iodine with sodium thiosulphate using starch as an external indicator. First, the liberation of free iodine from the salt is carried out by adding concentrated sulfuric acid (H<sub>2</sub>SO<sub>4</sub>) which liberates the free iodine from the iodate in the salt

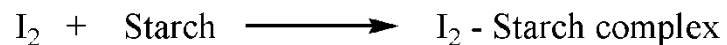
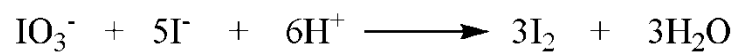
sample. Excess KI is added to solubilize the free iodine, which is quite insoluble in pure water under normal conditions. Free iodine is consumed by sodium thiosulfate in the titration step [53, 54].

### **2.15. Rapid test kit**

Rapid test kits apply to both qualitative and semi-quantitative estimations of iodine content. These kits are rapid, simple and easily applied in a field setting, and need no training of chemistry laboratory personnel. Spot tests can be used at sites of production, distribution, retail, and household. They are especially suitable for small-scale salt producers who may not be able to achieve the level of sophistication needed to establish more quantitative laboratory titration methods. There are various spot tests available, all of which use the same common reaction mechanism, and a starch-based reagent solution that produces a blue color when iodine is present in a salt sample [55, 53]. The semi-quantitative estimation of the salt iodine is based on the reaction between starch and iodine to form a starch-iodine complex. This test solution contains an acidic buffer and a reducing agent, which convert  $\text{KIO}_3$  to elemental iodine ( $\text{I}_2$ ). Thus the accuracy of coverage estimates can be established and the usefulness of rapid test kits verified. However, titration remains the method of choice for establishing the coverage of the percentage of households using salt containing  $>15$  parts per million (ppm) [49].

### **2.16. Spectrophotometric Method**

Iodine content can be determined using both direct and indirect methods. The direct method is known as iodimetry, while the indirect method is known as iodometry. It is carried out spectrophotometrically by reacting iodate with excess iodide in the presence of an acid. The formed iodine reacts with variamine blue and produces a purple-colored complex, which is measured at 550 nm. The principle of the spectrophotometric method for measuring the iodate content in salt is based on the reaction between iodate and iodide in an acidic condition to form iodine. Iodine reacts with starch solution to form the blue iodine–starch complex [56]. The principle of the reaction is shown as:



Optimization of chemical parameters measurement at the maximum wavelength has high accuracy and reduces measurement errors. The absorbance of the iodine starch complex increased with the increase in scanning wavelength. However, after passing through the maximum wavelength

### 3. MATERIAL AND METHODS

#### 3.1. Description of the study area

The study was conducted in Jimma town (Markato, Bore, Kochi, Ajip and Ginjo ) which is located 354 km southwest of Addis Ababa, the capital city of Ethiopia. It is found in the Oromia region and it is one of the biggest towns in the Southwestern part of the country. It lies at an elevation of 5,740 feet (1,750 meters) in a forested region known for its coffee plantations. It serves as the commercial center for the region, handling coffee and other products. Latitude and longitude of Jimma is 7°40'N 36°50'E/7.667°N 36.833°E. As presented in the below map.

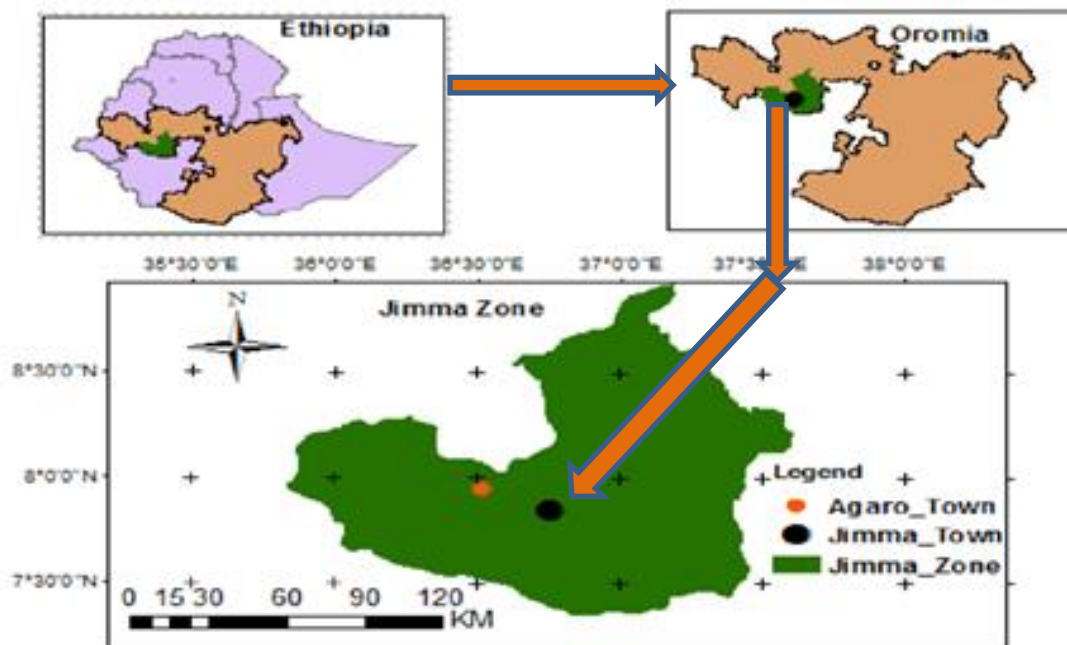


Figure 4. Map of Jimma, source Google map (<https://mapcarta.com/jimma>)

#### 3.2. Study design

For knowledge, attitude and practice assessment a purposive sampling technique and Semi-structured questionnaires were used to get information from ninety participants, 30 Retailers and 60 consumers aged above 18 male and female were engaged in the survey. The questionnaire was developed and it had three parts; the first part was general information

about handling, the second part was about usage and the final part was KAP related to the factor affecting iodized salt..

### **3.3. Equipment and materials**

The equipment and materials used in this research were a beaker, hot plate, measuring cylinder, volumetric flask, glass rod, electronic balance, graduated pipette, burette with stand, Erlenmeyer flask and aluminum foil.

### **3.4. Chemicals and Reagents**

Potassium iodate Sodium thiosulfate, Sulfuric acid, Potassium iodide, Starch, Iodine rapid test kit solutions, and distilled water.

### **3.5. Eligibility criteria for sample collection**

Salts having two months and above of shelf life, before expiry date, the same batch numbers, properly sealed and non-leakage were selected for analysis. Also for KAP assessment male and female above 18 years old and iodized salt user were participated.

### **3.6. Sample collection and preparation**

As the table below 10 different salt brands for each brand 3 packets total, 30 salt packets from selected market areas (Markato, Bore, Kochi, Ajip, and Ginjo ) were appropriately purchased by the researcher and were kept in the dark place until analysis. The privacy of salt samples was distinguished by the name on the packet. Since iodine occurs in an extremely homogeneous fashion in salt commodities, incremental sampling is done to make an aggregate sample consisting of subsamples from every part of a sack. Then, 100g of the sample is weighed and zipped with a plastic bag. Finally, 10g of analytical sample was taken for analysis.

Also, a total of 90 participants (60 consumers and 30 retailers) selected from Bore kebele were assessed for KAP by using semi-structured questionnaires. The Kebele had 5 zones, each zone had 23 sub-villages (locally called Gare) and each sub-village had 30 households. For this study 6 sub-villages, from each sub-villages 15 households were purposively selected. The questionnaire was developed and it had two parts; the first part Socio-

demographic, the second part was general information about iodized salt, handling, usage and factor affecting iodized salt.

**Table 4. Description of sample**

<b>S.No.</b>	<b>Sample name</b>	<b>Amount in No</b>	<b>Labeled iodine (mg/kg)</b>	<b>Production date</b>	<b>Expiry date</b>	<b>Processed in</b>
1	NM	3 packets	20-50	10/1/23	10/06/24	Ethiopia
2	Abay	3 packets	NG	8/11/23	8/11/24	Ethiopia
3	Shega	3 packets	50	1/2 /23	1/1/25	Ethiopia
4	Liq	3 packets	20-40	6/11/22	1/1/24	Ethiopia
5	Afar	3 packets	NG	3/ 12/022	3/12/2024	Ethiopia
6	Jimma	3 packets	NG	7/1/ 2023	7/1/ 2024	Ethiopia
7	Jimmitti	3 packets	NG	16/2/23	16/2/23	Ethiopia
8	Berta	3 packets	33-64	20/9/22	20/9/24	Ethiopia
9	Gold	3 packets	33-64	12/11/2022	12/11/ 2025	Ethiopia
10	Koketi	3 packets	20-40	1/2/2023	1/2/2025	Ethiopia

**NG: Not given**

### **3.7. Data quality control and assurance measurements**

Great weight was given to data quality control and assurance starting from data collection, laboratory testing, data entry and statistical analysis. The instrument's standard quality and laboratory reagents were checked. A salt sample was taken after carefully homogenizing each salt packet because iodine content may be different in samples taken from the same container of different depths. Laboratory analysis of all samples was performed in triplicates. Special emphasis was paid to data entry to software and the final result was checked repeatedly to ensure overall data quality.

### **3.8. Preparation of standard solution and reagents**

0.005N Sodium thiosulfate: weighed mass of 1.24 g  $\text{Na}_2\text{S}_2\text{O}_3 \cdot 5\text{H}_2\text{O}$  was sited into the one-liter volumetric flask. Then distilled water was added in a lesser amount and shaken until the solute dissolved. Finally, distilled water was filled up to 1 liter mark.

2N sulfuric acid: 8 mL of concentrated  $\text{H}_2\text{SO}_4$  was added to 100 mL of distilled water and made up to 150 mL with water.

10% potassium iodide: 100 g of potassium iodide was weighed and transferred into a 1000 mL volumetric flask. After that distilled water was added to the flask in a small amount and the solution was shaken until the solute dissolved. Then distilled water was filled up to 1000mLmark and stored in a cool, dark place.

1% Starch solution: weighed mass of 1g of starch was transferred into a 100 mL beaker. Then distilled water was added up to 100 mL mark and heated to dissolve.

0.01N standard potassium iodate solution: 0.018 g of standard potassium iodate was accurately measured and placed into a 50 mL volumetric flask. Distilled water was added to the flask in a small amount and shaken until the solute dissolved. Then flask was filled with distilled water, up to 50 mL mark [46].

### **3.9. Standardization of sodium thiosulfate solution**

The sodium thiosulfate solution should be standardized with standard potassium iodate solution to determine its exact normality. 15 mL of 0.01N  $\text{KIO}_3$  solution was pipetted out into 250 mL Erlenmeyer flask and 1 mL of 2 N sulfuric acid and 5 mL of 10 % potassium iodide solution were added. Then flask is covered with aluminum foil and retained in the dark for 10 minutes. After the specified time, the flask is taken out of the dark and titrated against sodium thiosulfate till the solution becomes pale yellowish. Then 2 drops of the starch solution were added and the solution turned blue-black. Finally, the solution is titrated again with thiosulfate solution till the blue-black color completely disappears. Then process is continued two more times and the average volume of thiosulfate is recorded to calculate the exact concentration of thiosulfate [49].

### 3.10. Validation of iodometric and RTK methods for testing iodine in the salt

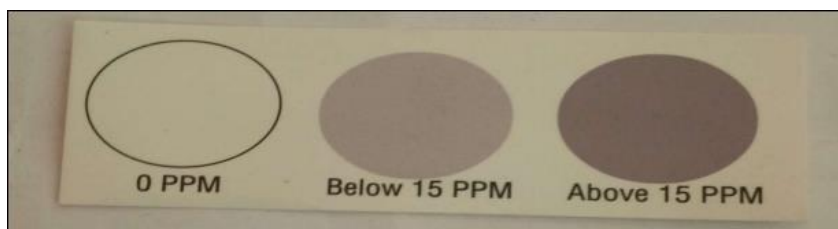
The titration method is recommended for the correct determination of the amount of iodine present in salt. Randomly Afar salt was selected and iodine content was measured 3 times using iodometric titration its average iodine concentration was used as a reference and again the salt was tested 3 times using RTK to confirm positivity and negativity with iodinated and non-iodinated salt, respectively. So each method was used to measure iodine levels in different salt brands. Iodometric titration is the most commonly used method and remains the reference method for determining iodine content in the salt.

### 3.11. Procedure for rapid testing kit

A small cup was filled with salt and the salt surface was spread flat. Then two drops of the test solution were added to the surface of the salt. After that, the color on the salt was developed and color on the salt was compared with the standard color chart, and iodine content was determined. Finally, the procedure was continued two more times. If no color appears on the salt after one minute, on fresh sample add up to five drops of recheck solution and then add two drops of test solution on the same spot. Finally, the sample color was compared with the standard color chart and determine the iodine content [49].



**Figure 5. Small cup was filled with salt**

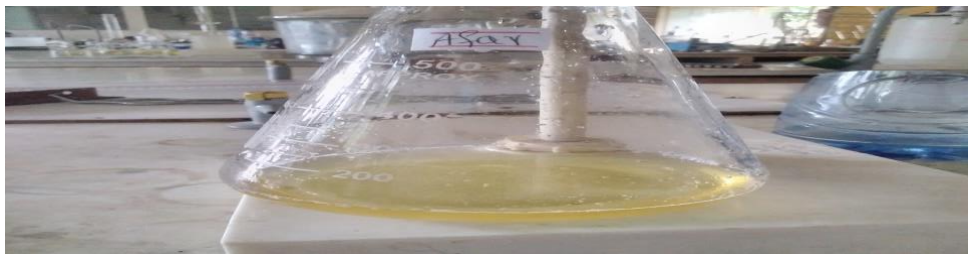


**Figure 6.WHO standard color chart**

### 3.12. Procedure for iodometric titration

10 g of salt sample was placed into 250 ml Erlenmeyer flask and 50 ml of distilled water was added to dissolve salt. Then 1 ml of 2N  $\text{H}_2\text{SO}_4$  and 5 ml of 10% KI were added to the salt solution and the solution turned yellow as iodine was produced. Finally, the flask is covered with aluminum foil and put in the dark for 10 minutes. Then, a cleaned burette was filled with 0.005N  $\text{Na}_2\text{S}_2\text{O}_3$ . After the specified time, the flask containing the solution was taken from the dark, and some thiosulfate was added from the titration burette with continuous gentle agitation until the yellow solution became pale yellow. Then, 2 drops of the starch solution were added and the solution turned to a blue-black color. Titration was continued until the solution color is turning to colorless. Finally, titration was repeated more than two times. The average volume of  $\text{Na}_2\text{S}_2\text{O}_3$  and concentration of iodine was determined

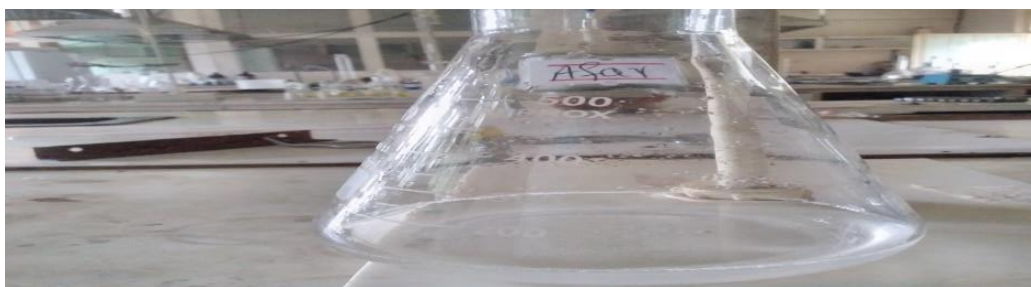
### 3.13. Photograph of color change in iodometric titration for Afar salt brand



**Figure 7. Pale yellow color left when nearly all iodine has reacted with thiosulfate**

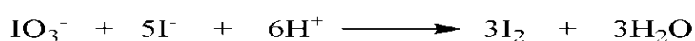


**Figure 8. Blue black color formed when starch indicator was added in pale yellow color solution.**

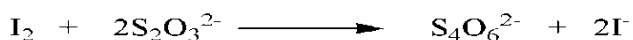


**Figure 9. Blue black color disappeared, leaving colorless solution at end point**

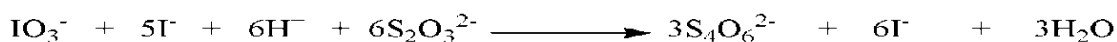
**Chemical equations are as follows:-**



Reduction of iodine with thiosulfate



Overall reaction



In an iodometric titration, the amount of iodine that will be liberated from salt is proportional to the amount of thiosulfate used during titration and the amount of iodine in salt is calculated by the following formula:

$$\text{Mg/kg (ppm) iodine} = V \times 21.15 \times N \times 1000 / \text{salt sample weight in g(M)}$$

V = Average volume of Na<sub>2</sub>S<sub>2</sub>O<sub>3</sub> in milliliter

21.15= Equivalent weight of iodine in gram per equivalent

N = Normality of Na<sub>2</sub>S<sub>2</sub>O<sub>3</sub> which is 0.005 equivalent per liter

1000= conversion factor to convert gram of iodine to milligram

M = Mass of salt sample weighted which is 10 gram

### **3.14. Data analysis**

Data were entered, cleaned, and checked before data analysis. The descriptive statistics were presented as frequency and percentage. Statistical analysis was conducted using SPSS version 26.

### **3.15. Ethical considerations**

The official letter was written for data collection from Jimma University Natural Science College. Participants' confidentiality and anonymity were kept. Informed verbal consent was also taken individually, and any respondents who were not assured were given a full right to refuse to participate in the study without any negative implication on their future service.

### **3.16. Strength and Limitation of the Study**

#### **3.16.1. Strength of the study**

Determination of iodine content in salt samples commercially available and KAP assessment of consumer and retailer was made an effort for the first time in Jimma town. Therefore, this study will provide baseline information for concerned bodies involved in determination of iodine content in salt samples commercially available and KAP assessment of consumer and retailer in Jimma town and other area of the country for further study.

#### **3.16.2. Limitation of the study**

This study determined the content of iodine at shop level and only from two processing areas. However, salt may lose its iodine content at manufacture level or during transportation before outgoing to retail level and purposive sample collection for KAP assessment.

## 4. RESULT AND DISCATION

### 4.1. Analytical Result

The iodine content of salt samples collected from retailer shops of Jimma town in 2023

After the procedure, as stated above the following results were obtained.

**Table 5. Iodine content of salt sample collected from different site.**

Sample site	Sample name /salt brand	Iodine content determined by	
		Iodometric titration (mean $\pm$ standard deviation) in (mg/kg)	Rapid test kit in (mg/kg)
Merkato	Koketi	82.05 $\pm$ 0.67	>15
	Liq	71.44 $\pm$ 0.82	>15
Ajip	Jimmiti	67.20 $\pm$ 0.06	>15
	Jimi	56.94 $\pm$ 0.28	<15
Ginjo	NM	43.14 $\pm$ 0.96	<15
	Abay	39.96 $\pm$ 0.67	<15
Kochi	Afar	35.37 $\pm$ 0.25	<15
	Shega	No content of iodine	0 ppm
Bore	Berta	No content of iodine	0 ppm
	Gold	No content of iodine	0ppm
From processing area	Koketi	82.76 $\pm$ 0.62	>15
	Jimi	57.65 $\pm$ 0.67	<15

As understood in Table 5, the iodine content of different salt samples commercially available in Jimma town was determined by iodometric titration and RTK. The iodometric titration results showed that the iodine content of salt samples was found within the range of 0 mg /kg to 82.05  $\pm$ 0.67 mg/ kg. This indicates that the majority of salt samples available in the study area showed over-iodized during processing time. The iodine content of Koketi and Jimma that was collected from the market was (82.05  $\pm$ 0.67) and (56.94  $\pm$ 0.28) while that collected

from the processing area was  $(82.76 \pm 0.62)$  and  $(57.65 \pm 0.67)$  respectively. Also, the result of Liq was  $(71.44 \pm 0.82)$ , Jimmiti  $(67.20 \pm 0.06)$ , NM  $(43.14 \pm 0.96)$ , Abay  $(39.96 \pm 0.67)$ , and Afar was  $(35.37 \pm 0.25)$ . Some samples like Shega, Gold and Berta during analysis did not show any color change, indicating those salts had content of iodine.

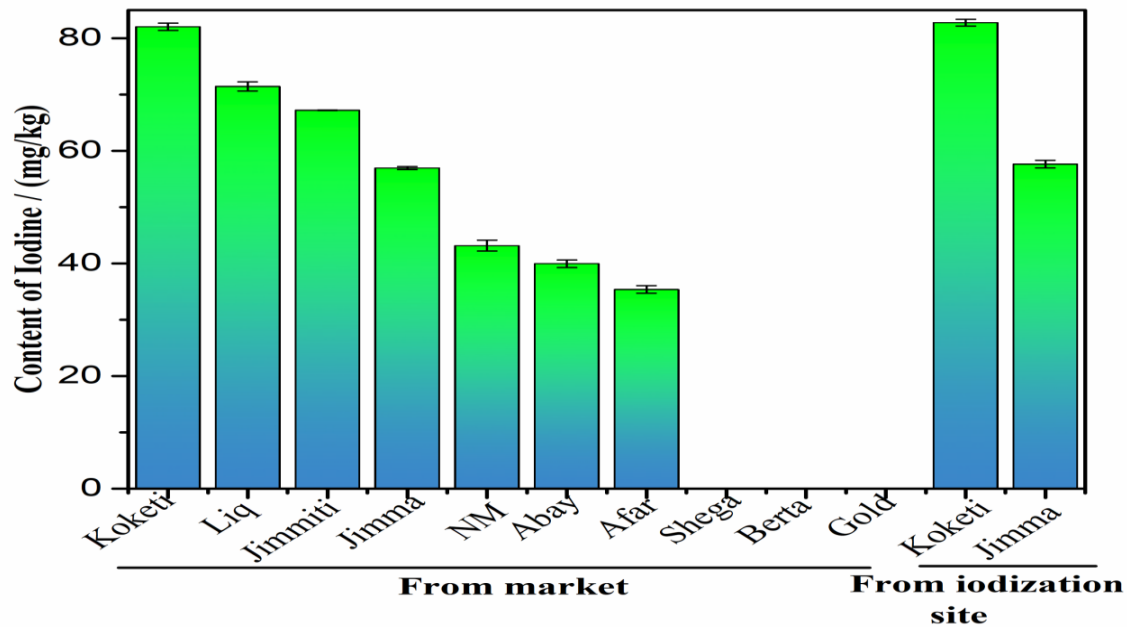
The iodine content leveled on a package of Koketi, Liq and NM was (20 - 40 mg/kg), on Berta and Gold was (33 – 64 mg/kg) and Shaga was (50 mg/kg). However, these were missed matches with the leveled-on package and were not confirmed during analysis. While the iodine content of Abay, Afar, Jimma and Jimmiti had not leveled on the package. However, those salts had iodine during the analysis as mentioned in Table.5.

These different values of iodine content in different table salt brands might be a lack of conformity of labeled iodine content, non-homogenous distribution of iodine amount added during iodization, poor mixing, uneven distribution within bags, poor quality of packet, exposure to high temperature and moisture during distribution, transportation, inaccuracy and faulty equipment at processing level and duration of salt storage at all level.

In 2017, a Study conducted in Ethiopia on the determination of iodine content of salt level showed that salt samples stored for a short duration were more likely to have adequate iodine content than those stored for a long duration [55, 33]. Another study conducted in London and Colombia showed that the time of salt storage had an impact on the level of iodine. Iodized salt will lose 24% iodine when stored for 10 weeks. This may be due to the effect of environmental factors like moisture content of salt, light, heat and other weather conditions [57].

A study conducted for determination of iodine level in consumer table salt from processing to consumption in Palestine, by studying the relationship between the date of processing and the percentage loss; found that the iodine loss increased as a result of shelf time increase for most salt brands. However, this study showed that the relationship between the date of processing and loss of iodine content is disproportion for most salt brands as shelf life increases may be due to long exposure to environmental factors and the quality of the container that the salt is packed with [18].

The salt iodine content determined by the RTK method showed that Koketi, Liq and Jimmiti salt brands had iodine content greater than >15 ppm and Abay, Jimma, NM and Afar salt brands had iodine content less than <15ppm. While Shega, Berta and Gold salt brands had 0 ppm iodine content. The reason for this might be because of exposure to factors which are listed above and differences in shelf life, which are left to expire. The result of iodized salt that collected from shops and processing level summarized in Figure below.



**Figure 10. Content of iodine in sample collected form selected site.**

According to WHO and QSAE in Ethiopia, iodization level of 15 -40 ppm and 36- 48 ppm is adequate level for human consumption respectively [47]. The iodization level of the iodine content of salt samples results compared with WHO and QSAE in below table 6 and 7.

**Table 6. Comparison of iodine with WHO and QSAE**

Level of iodization according to WHO	<u>NO</u>	Proportion (%)
Non iodized (<5 ppm)	3	30
Insufficiently iodized (5-14.9 ppm)	0	0
Adequately iodized (15-40 ppm)	3	30
Over iodized (>40 ppm)	4	40

**Table 7. Comparison of iodine with WHO and QSAE**

Type of Salt	Titration Result (mg/kg)	WHO's Standard	QSAE
Afar	35.37 ±0.25	Met	Met
Abay	39.96 ±0.67	Met	Met
Berta	0	Not fulfill	Not fulfill
Gold	0	Not fulfill	Not fulfill
Jimma	57.65 ± 0.67	Not fulfill	Not fulfill
Jimmiti	67.20 ±0.06	Not fulfill	Not fulfill
Koketi	82.05 ±0.67	Not fulfill	Not fulfill
Liq	71.44 ±0.8	Not fulfill	Not fulfill
NM	43.14 ±0.96	Not fulfill	Met
Shaga	0	Not fulfill	Not fulfill

As understood in tables 6 and 7, according to WHO and QSAE recommended level of iodization, the iodine content from the total of ten (n = 10) salt samples, 30% (n = 3) were non-iodized, 30% (n = 3) were adequately iodized, 40% (n=4) were over iodized. 40% of salt brands collected from selected retailer shops contained over the amount of iodine.

According to QSAE, 30% of different salt brands commercially available in Jimma town of the selected area did not contain adequate levels of iodine except Abay, NM and Afar salt, which contained adequate level of iodine out of ten salt samples collected. 30% of inland salt samples were noniodized and 40% over iodized. It can be forecasted that most of the consumers and retailers in the study areas were deprived of the required amount of iodine in the salts. These might be due to inadequate iodization, long exposure to moisture, sunlight, quality of packaging material and storage condition.

In one study, conducted in New Delhi, due to exposure to sunlight, packing nature and storage place at the processing and retail level there was about 31% loss of iodine from iodized salt [55]. Another study conducted in Canada showed that the iodine content of salt remained constant and its distribution remained uniform for many months when the salt was packed and kept in a dry and cool place and away from light [46].

Studied the homogeneity in iodized salt and the researcher found that iodine content varied in samples taken from the same container of different depths. It may be due to poor quality control and assurance in controlling and monitoring iodine content in iodized salts during iodization, storage and distribution [33, 40].

In this study, according to the level of the specification set by QSAE, only (30%) out of 10 salt samples contained adequate iodine content which is high when compared to the study conducted in Senegal (10%), Sudan (14.4%) and in Haiti (11%) in 2012. Also high when compared to the study conducted in Kenya in 2015 (26.2%). According to WHO's recommended level of iodization, the proportion of adequate iodine content in salt in this study is (30%) which is lower compared to studies conducted in Nigeria (95%), Ghana (75.6%), India (64%) and Tajikistan (71%). The reason for this might be the difference in technology to recover iodized salt, lack of enforcement in legislation and quality-controlled iodization technology at processing sites, storage and packaging [58].

One study conducted in India showed that most of the salts collected contained iodine levels in the acceptable range (15 ppm and above). Out of five samples, only one was shown to have poor iodine content [17]. Another study conducted in Dera district; northwest Ethiopia identified that three (60%) out of five salt samples had acceptable iodine content according to WHO's recommended level [59]. Which is higher compared to this study (30%).

## **4.2. Survey result**

### **4.2.1. Socio-demographic status of retailers and consumers**

The socio-demographic facts of the participants in this study are shown in Table 9. A total of 90 participants (60 consumers and 30 retailers) were included during the interview. Of the total 90 participants, the majority 50 (55.6%) were 20 - 30 years old. The educational status of the respondents was 17 (18.9%) illiterate, 25 (27.8%) grade 1 – 6, 18 (20.0%) grade 7 – 12 and 30 (33.3%) college and above.

**Table 8.** Socio demographic characteristics of iodized salt retailer and consumer.

	<b>Alternative</b>	<b>Frequency</b>	<b>%</b>
Age	20-30	50	55.6
	31-50	38	42.2
	>51	2	2.2
Sex	Male	49	54.4
	Female	41	45.6
Educational status	Illiterate	17	18.9
	1-6 grades	25	27.8
	7-12 grades	18	20.0
	Higher institution	30	33.3
Monthly Family Income	<2000	9	10.0
	2000-5000	44	48.9
	> 5000	37	41.1

#### **4.2.2. Knowledge status consumers**

Responses given by the participants on the knowledge questions as presented in Table 9 below, majority 34 (56.7%) of the respondents indicated that they knew about iodized salt and about 26 (43.3%) of the respondents didn't know about iodized salt. The study indicated that 19 (31.7%) knew about iodine loss from salt and 41 (68.3%) didn't know about iodine loss from salt.

Also, the selected consumers were asked whether they had selection criteria for iodized salt or not. About 32 (53.3%) of the respondents have selection criteria and 28 (46.7%) didn't have selection criteria for iodized salt. They further replied with some of the points to select iodized salt like shelf life, packaging material, whether it is sealed or not and absence of leakage.

Furthermore, 48 (80%) of the respondents knew favorable storage conditions for iodized salt but 12(20%) didn't know how to store iodized salt. 2(3.3%) of the respondents replied that they prefer to keep salt in a moist place, 2(3.3%) prefer to store iodized salt near the fire, 52

(86.7%) responded that they stored iodized salt at a dry and cool place and about 4(6.7%) responded they didn't consider anything where to store iodized salt.

Also, another question was asked to respondents on the effect of storing iodized salt for a long period. About (54%) of the respondents responded they knew the problem of storing iodized salt for a long period and (40%) of the respondents said no problem and 6% didn't know the problem of storing iodized salt for a long period. On average knowledge of the selected consumers on iodized salt was about 31.75%.

**Table 9.** Frequency distribution of consumer knowledge regarding iodized salt usage, storage and practice

<b>Variable</b>	<b>Alternative</b>	<b>Frequency</b>	<b>Percentage</b>
What is iodized salt? Can you describe it? (Do you know about iodized salt?)	Yes	34	56.7
	No	26	43.3
Do you have information about iodine loss from salt?	Yes	19	31.7
	No	41	68.3
	I don't know	11	18.0
Do you have selection criteria for quality iodized salt?	Yes	32	53.3
	No	28	46.7
What is your selection criterion?	Shelf life	6	9.8
	Packaging material	16	26.6
	properly sealed	20	32.8
	Non leakage	2	3.3
	Other (all)	16	26.2
Do you know favorable storage conditions for iodized salt?	Yes	48	80.0
	No	12	20.0
Which storage conditions are favorable for iodized salt?	Moist	2	3.3
	Near fire	2	3.3
	Dry and cool	52	86.7
	I don't know	4	6.7

Do you get problem when you are store iodized salt for long period of time	Yes	33	54.0
	No	23	40.0
	I don't know	4	6.0
What type of problem that occur during storage	Iodine loss	20	32.8
	Leakage	10	16.4
	Other	30	49.2

#### 4.2.3. Attitude status of consumers

Generally, 91% of consumers responded that iodized salt is used for human health. However, 43% of consumers could directly respond as it is used for goiter and mental retardation but 57% of consumers could not respond for what type of health it is used, they wrongly responded as it is used for the prevention of hypertension, kidney disease and skin rash. 90 % of consumer ware prefers packed salt to coarse salt for consumption and 93% of consumer knows the difference between packed and coarse salt. 57% of respondents gave their reason why they prefer packed salt because it is ready to use while 25% of respondents gave their reason as it is iodized with iodine, 15% replied as it is ready to use and 3% prefer coarse salt because of widely used and has high iodine content and make food sweaty. 43 % of respondents knew salt iodized with iodine while 52% didn't know. 5% said that it is not iodized with iodine. 70 % of respondents didn't know mechanism of iodine loss from the salt while 30% knew. Only 7% were exactly replied that favorable conditions like storage conditions, exposure to light, heat and cooking cause iodine loss and 5 % of respondents didn't reply. Also, 43% of consumers said that only storage condition, 25 % said that adding during cooking and 20 % said that exposure to light causes iodine loss. On average the attitude of the selected consumers on iodized salt was about 35.71%. This is presented in below table 10.

**Table 10.** Frequency distribution of consumer attitude regarding iodized salt usage, storage and practice

Variable	Alternative	Frequency	Percentage
Do you think iodized salt used for human health?	Yes	55	91.7
	No	3	5.0
	I Don't Known	2	3.3
What type of health?	Goiter	23	38.3
	mental retardation	3	5.0
	I don't know	34	56.7
What type of table salt you prefer for consumption?	packed salt	54	90
	core salt	6	10.0
Is there difference between packed and core salt?	Yes	56	93.3
	No	4	6.7
What the difference is between packed and core salt?	Packed salt Ready to use	34	56.7
	Packed salt has iodine	15	25.0
	All	9	15.0
	core salt has iodine more	2	3.3
Do you think table salt can iodized with iodine?	Yes	26	43.3
	No	3	5.0
	I don't know	31	51.7
Do you think iodine can loss from salt?	Yes	18	30.0
	I don't know	42	70.0
Which conditions are favorable for iodine loss?	Storage condition	26	43.3
	Adding during cooking	15	25.0
	Exposure to light	12	20.0
	All	4	6.7
	I don't know	3	5.0

#### 4.2.4. Practice status of consumers

The majorities of consumer (87%) got iodized salt from a Shop, 10 % from open market and only 3% from Super market .Also 62% of consumer’s respondent had habit to clean and dry the store before storing and 38% not had. In the same way 38 % of consumer stored iodized salt for long period of time, while 62 % of consumer didn’t store for long period of time. Similarly 70 % of consumer ware stores their salt on rack, 25% on ground and 5 % near fire. About 72 % of consumer closed their salt during storage while 28 % didn’t close. During storage 83 % of consumer ware store in closed plastic container while 16 % closed in open plastic container. Also during storage 80 % of consumer did not have protection mechanism for preventing iodine loss from the salt only 20% did have. 83 % of consumer did not recommend using expire and damaged iodized salt consumption, they believe that if expire and damage the iodine can be simply losses from the salt while 17 % replied as they recommended. On the average the practical knowledge of the selected consumers on iodized salt were about 40.14%. This summarized in below Table 11.

**Table 11.** Frequency distribution of consumer practice regarding iodized salt usage, storage and practice

Variable	Alternative	Frequency	Percentage
Where do you get iodized salt?	Open market	6	10.0
	Shop	52	86.7
	Super market	2	3.3
Do you store iodized salt for long period of time?	Yes	23	38.3
	No	37	61.7
Do you have the habit to clean and dry the store before storing of iodized salt?	Yes	37	61.7
	No	23	38.3
Where do you store iodized salt for long time?	On ground	15	20.0
	On rack	42	70.0
	Near fire	3	10.0
Do you close iodized salt before storage?	Yes	43	71.7
	No	17	28.3
How do you close iodized salt?	In closed plastic	50	83.3

	container			
	In open plastic	10		16.7
	container			
Do you have protection mechanism for preventing iodine loss?	Yes.1	After	12	20.0
	cooking			
When do you use iodized salt?	No.2	during	48	80
	cooking			
Do you recommend using expire and or damaged iodized salt? Why?	Yes		10	16.7
	No		50	83.3
Do you used expire and damaged packed salt?				

#### 4.2.5. Knowledge status of retailers

Retailers were interviewed for their knowledge, attitude and practice (KAP) regarding iodized salt usage, storage and practice. Responses given by the participants on the knowledge questions are shown in below Table 13. 23 (76.7%) of the respondents indicated that they did not know about iodized salt and 7 (23.3%) of the respondents knew about iodized salt. The study indicated that 3 (10%) know about iodine loss from salt and 27 (90%) didn't know about iodine loss from salt. Also the selected consumers were asked whether they have selection criteria for iodized salt or not. About 6 (26.7%) of the respondents have selection criteria and 23 (76.7%) didn't have selection criteria for iodized salt.

They further replied some of the points to select iodized salt like shelf life, packaging material, whether it is sealed or not and absence of leakage. Furthermore, 25 (83.3%) of the respondents know a favorable storage conditions for iodized salt but 5 (16.7%) don't know how to store iodized salt. 1(3.3%) of the respondents replied that they prefer to keep salt at moist place, 4 (13.4%) prefer to store iodized salt at hot and moist, 25 (83.3%) responded that they store iodized salt at dray and cool place.

Another question asked to respondent was the effect of storing iodized salt for long period of time. About 17 (56.7%) of the respondents were responded they knew the problem of storing iodized salt for long period of time and 13 (43.3%) of the respondents didn't know the

problem of storing iodized salt for long period of time. On the average the Knowledge of the selected retailers on iodized salt were about 12.37%.

**Table 12.** Frequency distribution of retailer knowledge regarding usage, storage and practice

Variable	Alternative	Frequency	Percent
Do you know about iodized salt? Can you Describe it?	Yes	7	23.3
	I Don't known	23	76.7
Do you have information about Iodine loss from salt?	Yes	3	10.0
	No	27	90
Do you have selection criteria for quality iodized salt?	Yes	8	26.7
	No	22	73.3
What is your selection criterion?	Shelf life	16	53.3
	Packaging	12	40.0
	Properly Sealed	2	6.7
Do you know favorable storage conditions for iodized salt?	Yes	25	83.3
	No	5	16.7
Which storage conditions are favorable for iodized salt?	Moist	1	3.3
	Dry and cool	25	83.3
	Hot and moist	4	13.4
Do you get problem when you are store Iodized salt for long period of time	Yes	17	56.7
	No	13	43.3
What type of problem that occur during storage	Iodine loss	4	13.3
	Leakage	14	46.7

#### 4.3. Attitude status retailers

83% of retailers responded that iodized salt used for human health. 70% of retailers could directly respond as it is used for goiter and mental retardation but 30% of retailers could not respond for what type of health as it is used, they were wrongly replied as it is used for

prevention of hypertension , kidney disease and skin rash. 100 % of retailers were prefers packed salt than coarse salt for consumption and 100 % knew the difference between packed and coarse salt. But 60% respondents gave their reason why they prefer packed salt because it is ready to use. While 40% respondents gave their reason as it is iodized with iodine, 10 % respondents knew as salt iodized with iodine while 77% didn't know and 13% said that it is not iodized with iodine. 70% of respondents didn't know how iodine is loss form the salt, while 27% of retailer knew about iodine and 3% said that iodine cannot loss from salt.

Also 23% were exactly replied that storage condition were favorable conditions,73% exposure to light and 3% during cooking cause for iodine loss. On the average the attitude of selected retailers on iodized salt were about 12.28%. This summarized in below Table 13.

**Table 13.** Frequency distribution of retailer attitude regarding iodized salt usage, storage and practice

Variable	Alternative	Frequency	Perce nt
Do you think iodized salt used for human health?	Yes	25	83.3
	No	5	16.7
What type of health?	Goiter	10	33.3
	Mental Retardation	11	36.7
	I don't known	9	30.0
What type of table salt you prefer for consumption?	Packed salt	30	100.0
Is there difference between packed and core salt?	Yes	30	100.0
What the difference between packed and core salt?	Packed salt ready to use	18	60.0
	Packed salt has iodine	12	40.0
Do you think table salt can iodized with iodine?	Yes	3	10.0
	No	4	13.3
	I don't known	23	76.7
Do you think iodine can loss from salt?	Yes	8	26.7

	No	1	3.3
	I don't know	21	70.0
Which conditions are favorable for iodine loss?	Storage condition	7	23.3
	Adding during cooking	1	3.3
	Exposure to light	22	73.3

## 1.2. Practice status retailers

All of consumers (100%) got iodized salt from a Shop. Also 77% of consumer's respondent had habit to clean and dry the store before storing and 23% not had. In the same way 47 % of consumer stored iodized salt for long period of time, while 53 % of consumer didn't store for long period of time. Similarly 93% of consumer ware stores their salt on rack, 7% on ground. About 70 % of consumer closed their salt during storage while 30 % didn't close. During storage 83 % of consumer ware store in closed plastic container while 17 % closed in open plastic container. Also during storage 77 % of consumer did not have protection mechanism for preventing iodine loss from the salt only 23% did have. 93% of consumer did not recommend using expire and damaged iodized salt consumption, they believe that if expire and damage the iodine can be simply losses from the salt while 7 % replied as they recommended. On the average the practical of retailers on iodized salt were about 21.42%.

**Table 14.** Frequency distribution of retailer practice regarding iodized salt usage, storage and practice

Variable	Alternative	Frequency	Percent
Where do you get iodized salt?	Shop	30	100
Do you store iodized salt for long period of time?	Yes	14	46.7
	No	16	53.3
Where do you store iodized salt for long time?	on ground	2	6.7
	on rack	28	93.3
Do you have the habit to clean and dry the store before storing of	Yes	23	76.7
	No	7	23.3

iodized salt?			
Do you close iodized salt before storage?	Yes	21	70
	No	9	30
How do you close iodized salt?	In closed plastic container	25	83.3
	In open plastic container	5	16.7
Do you have protection mechanism for preventing iodine loss?	Yes (after cooking )	7	23.3
	No (during cooking )	23	76.7
When do you use iodized salt?			
Do you recommend using expire and or damaged iodized salt? Why?	Yes	2	6.7
	No	28	93.3
Do you used expire and damaged Packed salt?			

In general, the average knowledge, attitude and practice of consumers on iodized salt were about 31.75%, 35.71% and 40.14% respectively. While the average knowledge, attitude and practice of retailers on iodized salt were about 12.37%, 12.28% and 21.42% respectively. In this study the consumers had batter knowledge , attitude and practice than retailers .When we compares this with the study conducted at Debre Tabor town showed that 430 (70.1%) had information on iodine nutrient , 391 (63.8%) knew about iodized salt and 330 (53.8%) of the participants had poor knowledge related to iodized salt consumption at household level [10].

On the other hand when we compares with study conducted at Bahirdar (2022), respondents whose scored 50% and above regarding iodized salt knowledge questions were leveled as good knowledge, whereas below 50% scored leveled as poor knowledge. This indicate that the people were selected from the study areas had little bite good when we compare with Debre Tabor town and had poor Knowledge, Attitude and Practice when we compare with Bahirdar [7].

## 5. CONCLUSION AND RECOMMENDATION

### 5.1. CONCLUSION

Iodine is vital micronutrient to human and required in trace amount. Salt iodization involves the addition of predetermined amount of iodine to the salt during production process to ensure the correct dosage of iodine as instructed by governmental standard. It is first line public health measure for preventing and controlling IDD in areas of poor iodine rich food.

In this study the iodine content of different salt samples determined by iodometric titration were found between zero (0mg / kg) to  $82.05 \pm 2.67$  mg/ kg. The highest value was recorded for koketi ( $37.252 \pm 0.603$  mg/kg) while the lowest value were recorded for Shaga, Barta and Gold. While iodine content of salts determined by rapid test kit (RTK) showed that for koketi, liq and Jimmiti  $> 15$ , for Jimma, NM, Abay and Afar  $< 15$  while for Shaga, Barta and Gold were zero ppm (0ppm) by both iodometric titration and RTK method.

When we compared the result of iodine content of salt with WHO and QSAE recommended level, from the total of ten ( $n = 10$ ) salt samples, 30% ( $n = 3$ ) were non iodized, 30% ( $n = 3$ ) were adequately iodized, 40% ( $n=4$ ) were over iodized. 40% of salt brands collected from selected areas contained over amount of iodine ( $>40$ ppm).

It is important to note that the low and excessive iodine intake can lead to adverse health effect and hence it is necessary to monitor the iodine content of salt and ensuring that it remains with in recommended range.

## 5.2. RECOMMENDATION

According to recommended level of iodization set by QSAE, 40% of salt samples available in Jimma town over iodized and almost one-third did not contained iodine. While in KAP assessment the majority of consumer and retailer were not aware iodized salt usage, storage, practice and mechanism of protection of iodine losses; so, the following are recommended;

- USI program in Ethiopia needs strict quality assurance measures at the stage of production, retail and consumption level for successful and sustainable prevention of IDD.
- Other iodine supplements should be added along with the diet to prevent IDD
- Awareness creation through Mass-media on the usage, storage, practice and mechanism of protection of iodine losses needed.

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## ANNEXES

### Annex-1 Questioner form

I am Remla Aba Temam who is a postgraduate student of Jimma University center for Natural Science, food safety and quality, conducting a study on the evaluation of iodine content and assess knowledge, attitude and practice of traders and consumers in Jimma town Omiya, Ethiopia. The purpose of my visit to know the knowledge, Attitude and practice (KAP) on handling and usage of iodized salt. If you are willing to participate in the study, I will ask you few questions for about 20 minutes. Your honest answers to these questions will help me for a better understanding of the topic, and will eventually help in designing and implementing appropriate interventions to alleviate related problems.

**Name of the interviewer Remla Aba Temam**

Signature \_\_\_\_\_

Date of interview \_\_\_\_\_

### Part I Socio-demographic Characteristics

	Question	Alternative	Remark
1	Age	1. 20-30	
		2. 31-50	
		3. >51	
2	Sex	1. Male	
		2. Female	
3	Marital status	1. Single 2. Married 3. Divorced 4. Widowed	
4	Educational status	1. Illiterate	
		2. 1-6 grades	
		3. 7-12 grades	

		4. Higher institution	
5	Monthly Family Income	1. <2000	
		2. 2000-5000	
		3. > 5000	
6	Occupation	1. House wife 2. Governmental employee 3. Private employee 4. Iodized salt traders 5. Daily laborer	

**Part II KAP assessment of consumer and retailer in Jimma Town (2023)**

	Question	Alternative	Instruction	Remark
	<b>Knowledge</b>			
1	What is iodized salt? Can you describe it?	1. Yes		
		2. I don't know		
2	Do you have information about iodine loss from salt?	1. Yes		
		2. No		
3	Do you have selection criteria for quality iodized salt?	1. Yes	If yes go to Q. No 4	
		2. No		
4	What are your selection criteria?	1. Shelf life		
		2. Packaging		
		3. Properly Sealed		
5	Do you know favorable storage conditions	1. Yes	If yes go to	

	for iodized salt?		Q. No 6	
		2. No		
6	Which storage conditions are favorable for iodized salt?	1. Moist		
		2. Dry and cool		
		3. Hot and moist		
7	Do you get problem when you are stored iodized salt for long period of time?	1. Yes	If yes go to Q. No 8	
		2. No		
8	What type of problem that occurs during storage?	1. Iodine loss		
		2. Leakage		
		3. Other		
<b>Attitude</b>				
9	Do you think iodized salt used for human health?	1. Yes	If yes go to Q. No 10	
		2. No		
10	What type of health?	1. Goiter		
		2. Mental Retardation		
		3. I don't known		
11	What type of table salt you prefer for consumption?	4. Iodized salt		
		5. Coarse salt		
12	Is there difference between packed and core salt?	1. Yes	If yes go to Q. No 13	
		2. No		
13	What is the difference between packed and coarse salt?	1. Packed salt ready to use		
		2. Packed salt has iodine		
		3. Coarse salt has iodine more		
		4. Other		

14	Do you think table salt can iodized with iodine?	1. Yes		
		2. No		
		3. I don't known		
15	Do you think iodine can loss from salt?	1. Yes	If yes go to Q. No 16	
		2. No		
		3. I don't known		
16	Which conditions are favorable for iodine loss?	1. Storage condition		
		2. Adding during cooking		
		3. Exposure to light		
<b>Practice</b>				
17	Where do you get iodized salt?	1. Shop 2. Open market 3. Super market		
18	Do you store iodized salt for long period of time?	1. Yes	If yes go to Q. No 19	
		2. No		
19	Where do you store iodized salt for long time?	1. On ground		
		2. On rack		
		3. Near fire		
		4. Other		
20	Do you have the habit to clean and dry the store before storing of iodized salt?	1. Yes		
		2. No		
21	Do you close iodized salt before storage?	1. Yes	If yes go to Q. No 22	
		2. No		
22	How do you close iodized salt?	1. In closed plastic container		

		2. In open plastic container 3. Other		
23	Do you have protection mechanism for preventing iodine loss?	1. Yes		
		2. No		
24	Do you recommend using expire and or damaged iodized salt? Why?	1. Yes		
		2. No		