Addis Ababa University

College of Natural Sciences

Center for Food Science and Nutrition

Adequacy of Iodine Content and Level of Contaminants in Edible Salts Produced In Ethiopia

BY:

Henok Araya

Advisor: Dr. Ashagrie Zewdu

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LIST OF ACRONYMS AND ABBREVIATIONS

AAS	Atomic absorption spectrometer
ANOVA	Analysis of variance
AOAC	Association of Official Analysis Chemists
AOS	African Organization for Standardization
ASTDR	Agency for Toxicology Substances and Disease Registry
APDC	Ammonium Pyrolidine Dicarbamate
CEE	Central and Eastern Europe
CSA	Central Statistical Agency
EDHS	Ethiopian Demographics and Health Survey
EPHI	Ethiopian Public Health Institute
ES	Ethiopian Standard
FAO	Food and Agriculture Organization
FAO	Food and Agriculture Organization
FCC	Food Chemical Codex
FAAS	Flame Atomic Absorption Spectrometry
EFMHACA	Ethiopian Food, Medicine, and Health care, Administration and Control Agency
FMoH	Federal Ministry of Health
GFFAS	Graphite Furnace Atomic Absorption Spectroscopy
ICCIDD	International Council and Control for Iodine Deficiency Disease
IDD	Iodine Deficiency Disorder
CIS	Common wealth of Independent States
IQ	Intellectual Quotient
Kg	Kilogram
LSD	Least Significance Difference
mg	milligram
NCC	National Codex Committee
PH	Hydrogen Ion Concentration

PTWI	Provisional Tolerable Weekly Intake
SPSS	Statistical Package for Social Science
T_3	Tri iodothyronine
T_4	Tetra iodothyronine
TSH	Thyroid Stimulating Hormone
UL	Upper Limit
UNEP	United Union Environment Program
UNICEF	United Nations Agency for International Development
US	United States
USFDA	United State Food Drug Administration
USI	Universal Salt Iodization
WHO	World Health Organization

ABSTRACT

Edible salt is the most commonly used food additive. Therefore, the quality of this important product needs to be certain as it can be a vehicle for a number of contaminants. This study was aimed to investigate the level of iodine, the content of sodium chloride, loss of mass, matter insoluble in water, sulphate, alkalinity, selected heavy metals and metal impurities, which are expected to be contained in edible salt. In order to determine the contents of table salt and common salt were collected from eight producers and re-packers which are located at different parts of the country. The levels of iodine were determined by iodotitration and metal impurities were estimated using FAAS after wet digestion of the salts. The value of iodine obtained for all analyzed samples were found to be within the range of 71.76 ± 8.09-4.24 ± 1.06 mg/kg in which 87.5 % of both common salts and table salts samples were lower than the Ethiopian Standard (ES) specification (60-80 ppm). The content of sodium chloride, Loss of mass, matter insolubility, sulphate, alkalinity and pH ranged between 96.13 ± 0.24-98.98.5 ± 0.29, 0.23 ± 0.05-2.66,0.18 ± 0.00- 2.16 ± 0.38,0.13 ± 0.10-5.15 ± 0.37, 0.12 ± 0.074 - 0.95 ± 0.01,7.85 ± 0.05-8.75 ± 0.02 respectively. The heavy metals Cadmium, Lead and Zinc content of the studied Table salt and Common salt remained lower than the permitted maximum for human consumption as prescribed by ES specification and codex. However, calcium impurities found to be 0.26 ± 0.05, 0.35 ±0.00, 1.63± 0.02, 1.52 ± 0.02,0.61 ± 0.01,0.41 ± 0.11,1.56± 0.52, 0.42 ± 0.02 which indicated that half of out of the four table salts samples meet the requirement set by the ES. Magnesium content were found to be 1.96 ± 0.01, 2.60 ± 0.01, 4.17 ± 0.02, 3.83 ± 0.03, 1.79 ± 0.01, 0.82 ± 0.01, 4.39 ± 0.09and 2.57 ± 0.03, respectively in which only two of the two table salts were below the ES. Iron content was ranged between 0.18 ± 0.00-0.56 ± 0.11, in which half values for iron in both common salts and table salts were lower than the permitted consumption level defined by ES. In general, the salts delivered to the community are poor in their iodine content the quality of both the common and table salts have to be improved through improving method of production and iodization as well. But, are safe with regard to their heavy metals such as Cd, Pb, Zn and Cu.

Key words: Salt, Iodine, Metal Contaminants, Sodium Chloride, Loss of Mass, Matter Insoluble, Sulphate, Alkalinity, Ethiopian Standard

1. Introduction

1.1. Background of the study

Most people probably think of salt as simple that white granular food seasoning found virtually on dining table. It is that surely, but it is more than that. It is biologically necessary because it provides two important macro elements of sodium and chlorine for human body. Sodium chloride, common salt, is essential to human life (Bloch,2006) . Our bodies contain up to 450 grams of salt and we need to take in a few grams each week to stay healthy Furthermore, it improves food taste, could serve as a preservative, and elongates shelf life. Generally, salt is the most additive used in food industry (Landforms ,1999).

The production of common salt is one of the most ancient and widely distributed industries in the world. Recently, the annual world production of salt has reached 200 million tons. Approximately one third of the total is produced by solar evaporation of sea water or inland brines. The rest are obtained by mining of rock salt deposits, both underground and on the surface (Leone,2012).

Salt production has a long history in north east Ethiopian in general and the Afar region in particular. It dates back to the long-distance trade of medieval times (Abir ,1968), and salt bar (amole) was widely used as a medium of exchange up to the mid twentieth century. In fact the source of all amole in circulation, which connected the various regions of Ethiopia, was the salt plains of the Afar lowlands located in the Denakil depression (Zewde, 2001). The rise and fall of politics in Northern Ethiopia was intimately connected to access to and control over the salt trade routes (Feyissa, 2011). After the independence of Eritrea in 1993, Ethiopia lost most of these salt mines. Salt supply had, however, continued unaffected after the break away of Eritrea up until the resumption of war between the two countries in 1998 (Feyissa ,2011).

The 1998 – 2000 Ethio – Eritrean war interrupted Ethiopia's salt supply from Eritrea .As a result, Ethiopia started importing salt from neighboring countries, particularly Djibouti (Feyissa, 2011). Seeking to avoid dependence on the international market, the Ethiopian government explored domestic sources of salt. Although a small amount of salt is available in underground water in Tigray and from rocks in Somali regions, abundant salt is found in the Afar National

Regional State, particularly from Lake Afdera. At present, Lake Afdera, located close to the Eritrean border, produces and distributes 95% of the total salt requirement of Ethiopia (Zewde, 2001). In fact, supply by far exceeds domestic demand. Ethiopia's annual domestic salt demand is estimated at 350,000 tons, whereas Afdera, alone has an annual production capacity of 1.2 million tons of salt (Feyissa, 2011).

Salt is produced by large (over 800 tons a month), medium (300 – 800 tons a month) and small-scale producers (fewer than 300 tons a month). There are 750 salt producers in Afdera (Feyissa, 2011). The Ethiopian Geological survey in 2007 reported, Ezana is one of the largest salt companies that operate in Afdera. It has the capacity to produce 250,000 tons of salt per year 71% of annual domestic product but currently produces only 30,000 tons a year because of a production quota system.

Food grade salt which is used for food uses account for 17.5% of salt production in the world (sedivy, 1996). According to CODEX standard (2001), food grade salt should be obtained from the sea, the lake underground rock salt deposits or from natural brine .The quality should be on the basis that NaCl should not be less than 97%. Salt, for human consumption is produced in different forms: unrefined salt, refined salt (table salt) and iodized salt which are the most widely used presently, is mainly sodium chloride.

Lake salts contain components leached from the ground of the surrounding rocks in variable quantities (Fergusson, 1982). Minor components (organic matter, heavy metals), and major components (K^+, Mg^{+2} , Ca^{+2}, water and clay are present as impurities in common salt (Masuzawa, 1979). In Ethiopia the quality and composition of edible salt is not well known (Abuye, et al., 2010). Since the edible salt is consumed daily, any contamination, even at low levels could be hazardous to the consumer's health.

Edible salt is the most commonly used vehicles for iodine as Universal Salt Iodization which is an effective, safe, sustainable and cost effective intervention strategy for prevention, control and elimination of iodine deficiency (Organization, 2007). Iodine deficiency in children results in learning disabilities and reduced achievement (Buxon C and Baguune, 2012). Even mild to moderate iodine deficiency has been shown to cause abnormalities in psychomotor and intellectual development in children (WHO, 2007). About 38 million newborns in developing countries every year remain unprotected from the lifelong consequences of brain damage associated with iodine deficiency disorder (UNICEF, 2008). Other consequences of iodine deficiency include hypothyroidism and crentism. Hypothyroidism is detected by low levels of thyroid hormones in the blood resulting in sluggishness, sleepiness dry skin, cold intolerance and constipation (Pongpaew, et al., 2002). Cretinism refers to the very consequences of hypothyroidism occurring at the fetal or neonatal life. In addition to having severe irreversible mental retardation, they may also present several other conditions including deaf mutism, short stature and retarded development of the musculo-skeleton system (Zimmermann, et al., 2008). Therefore, the study was aimed to evaluate the amount of iodine and analyze the quality composition of edible salt. Since, it's important to assess the quality of chemical compositions when planning iodization.

1.2. Statement of the problem

Sedivy (1996) states that salt can be obtained by evaporation of sea water, usually in shallow basins warmed by sunlight; and called sea salt or solar salt. A rock salt deposit are formed by the evaporation of ancient salt lakes, and may be mined conventionally or through the injection of water dissolves the salt, and the brine solution can be pumped to the surface where the salt is collected. After the raw salt is obtained, it is refined to purify it and improve its handling characteristics (Götzfried and Kondorosy, 2009).

Purification usually involves re-crystallization .In re-crystallization; a brine solution is treated with chemicals that precipitate most of its impurities (largely magnesium and calcium).Multiple stages of evaporation are then used to collect pure sodium chloride. The purity of washed solar salt can reach 99 - 99.5% (NaCl, dry bases) in India and China and 99.7% in Australia and Mexico. Vacuum salt is usually 99.8 - 99.95% pure (Götzfried and Kondorosy, 2009).

The Geological Survey of Ethiopia (2007) reported that Local companies produce salt from the lake by pumping the brine into artificial ponds for evaporation and subsequent precipitation. According to my personal observation the brine solution pumped out of the Lake of Afdera and Dobi do not undergo chemical treatment. Since there is a constant geologic turmoil that results in volcanic ashes which continually added to the surrounding as impurities. Failure to purify the brine adequately may have serious, even lethal consequences (Sedivy, 1996).

Recognizing the extent of iodine deficiency and the disorders that could emanate from lack of iodine , the Federal Ministry of Health of Ethiopia launched an IDD (Iodine Deficiency Disorder) prevention and control program as part of the National Micronutrient Deficiency Disorders prevention and control program in 1996 (FMoH,2004). But, until now only 15.4% of households using iodized salts.

A comphransive review of the literature concluded that the stability of iodine is determined by the moisture content of the salt, humidity, light, heat impurities, alkalinity or acidity (Diosady and Albert, 1998).

There are rare previous published studies related to the present work, regarding the chemical compositions (qualities) of edible salts produced in the country.

1.3. Objective of the study

General objective

To analyze the adequacy of iodine content and evaluation of contaminants in edible salt produced in Ethiopia.

Specific objectives

- To determine the iodine contents of edible salts collected from the producers and re-packers.
- To estimate the accumulation of some of the heavy metals such as Cadmium, Lead, Zinc and Copper in edible salt.
- To analyze sodium chloride, alkalinity, sulphate, moisture content, matter insoluble and pH of edible salt.
- To determine some of the metal impurities such as Calcium, Magnesium and iron in the edible salt.

1.4. Hypothesis

The iodine content, pH, alkalinity, sulphate, moisture content, matter insoluble, and level of some of the trace elements cadmium, copper, zinc, and metal impurities such as iron, calcium and magnesium of edible salt produced in Ethiopia are not significantly different from the level set by Ethiopian Standard.

1.5. Significance of the study

In Ethiopia proclamation number 5/2011 has been enacted to make sure the quality and safety of iodized edible salt delivered to the public is of acceptable standards (EFMHACA, 2011).

All materials in the salt should be of edible grade, clean and free from extraneous matter. It should also satisfy the standard requirement .There is law which forced all the players in salt business. The edible salt quality and composition in Ethiopia is not well known (FMoH, 2005). When planning for iodization it is important to assess the quality of edible salt in terms of chemicals composition and physical contaminants. Therefore, the study provides information regarding chemicals composition of edible salt to improve the quality and level of iodine which is added to edible salts produced in the country.

This study will fill certain gaps and initiate other researchers for further study regarding the quality composition of edible salt.

2. Literature Review

2.1. Types of salt

Salt for human consumption is produced in different forms: unrefined salt (such as sea salt), refined salt (table salt), and iodized salt. It's a crystalline solid, white, pale pink or light gray in color, normally obtained from sea water or rock deposits. Edible salts may be slightly grayish in color because of mineral content (Sedivy, 1996).

2.1.1. Unrefined salt

Unrefined salt does not under go through the purification process which are commonly used as ingredients' in bathing additives and cosmetics products. One example is bath salts, which uses sea salt as its main ingredients and combined with other ingredients used for healing and therapeutic effects (Sedivy, 1996).

2.1.2. Iodized salt

Iodized salt is table salt mixed with a minute amount of potassium iodide or potassium iodate. Iodized salt is used to help reduce the incidence of iodine deficiency in humans (Zimmermann, 2007).Table salt is refined salt, which contains about 97% to 99% sodium chloride. It usually contains substances that make it free-flowing (anti-caking agents) such as sodium silcoaluminate or magnesium carbonate. Some people also add a desiccant, such as a few grains of uncooked rice, in salt to absorb extra moisture and help break up clumps when anti-caking agents are not enough (Sedivy,1996).

2.1.3. Refined salt

Refined salt, which is most widely used presently, is mainly sodium chloride. Food grade salt accounts for only a small part of salt production in industrialized countries (3 % in Europe) although worldwide, food uses account for 17.5% of salt production. The majority is sold for industrial use. Salt has great commercial value because it is a necessary ingredient of wide applications (Sedivy, 1996).

2.2. Significance of salt

Salt is the oldest known food additive and still remains an essential requirement of any household contributing its own basic salty taste. Salt brings out natural flavors' and makes food acceptable, protects food safety by retarding the growth of spoilage microorganisms (Bloch, 2006). Salt gives proper texture to processed foods, serves as a control agent to regulate the rate of fermentation in food processing, strengthens gluten in bread, provides color, aroma and appearance consumers expect and is used to create the gel necessary to process meats and sausages (Usman and Fiili, 2013).

In recent years food editors and those that know much about salt and have high interest on it, have frequently extolled the virtues of the wide variety of salt available for cooking and table use (Sedivy, 2009).

2.3. Methods of salt production

There are three methods of salt production: solar evaporation, rock mining and vacuum mining. Solar evaporation is the oldest method of salt production .It has been used since salt crystals were first noticed in trapped pools of sea water. Its use is practical only in warm climates where the evaporation rate exceeds the precipitation rate, either annually or for extended periods, and ideally, where there are steady prevailing winds .Solar production is, typically, capturing of salt water. The concentrated brine precipitates the salt which is then gathered by mechanical harvesting. Any impurities that may be present in the brine are drained off and discarded prior to harvesting. Usually two types of ponds are used. First is the concentrating pond, where the salty water from the ocean or salt lake is concentrated. The second is the crystallizing pond, where the salt is actually produced. Rock salt mining method use large machines travel through vast cave-like passageways and performing various operations (Sedivy ,1996). Vacuum Evaporation is the evaporation of salt brine by steam heat in large commercial evaporators, called vacuum pans. This method yields a very high purity salt, fine in texture, and principally used in those applications requiring the highest quality salt (Sedivy, 2009).

In vacuum pan process, steam is fed to the first pan. This causes the brine in the pan to boil. The stream from the boiling brine is then used to heat the brine in the second pan. The pressure in the second pan is lower; allowing the steam made by the boiling in the first pan to boil the brine in the second pan. The pressure is reduced still further in each succeeding pan. This allows the steam made by the boiling brine in the previous pan to boil the brine in the next pan. While the boiling operation could be done with just one pan, several pans in a row produce more salt per kilogram of steam, thus allowing greater energy efficiency (Götzfried and Kondorosy 2009).

2.4. Iodine

Iodine is a micronutrient and an essential component of thyroid hormones that is tri iodothyronine (T_3) and tetra iodothyronine (T_4). Daily requirement of iodine for normal function of thyroid gland is150-200 micro grams (µg) in adults, 90-120µg in children and 250µg for pregnant & lactating mothers. Total body contains 25-30 mg of iodine, 80% of which is present in thyroid gland and rest in all other cells. Iodine level in blood is 5-10 micro grams per deciliter (Kusić and Jukić, 2005).

Best source of iodine are sea food (e.g. sea fish, sea salt) and cod liver oil. Small amount of iodine is present in milk, meat, vegetables, cereals and fresh water. Iodine content of fresh water is 1-50µg per liter (Ahmad, et al., 2012). Other indirect sources of iodine which may contribute to the total iodine content of foods include sources such as veterinary drugs used on animal's food additives, such as calcium iodate used in baking as a dough conditioner and erythrosine, used as red food coloring. However, the bioavailability from these indirect sources is low and therefore, is not regard as significant. Many countries permit for the addition of iodide to table salt (Sumar and Ismail ,1997). The legal framework in Ethiopia is the salt iodization regulation No.204/2011 which impose legal obligation on producers, distributers, importers and all individuals involved in salt trade to ensure the salt for human consumption is adequately iodized i.e., based on the specification set by the Ethiopian Standard (EFMHACA, 2011).

2.5. Iodine deficiency

In the world, there are almost no developing countries where iodine deficiency was not a public health problem (WHO,2008). About 2.2billion of population and 266 million school aged children live in areas with iodine deficiency (Hailay and Digsu, 2013). In developing countries750 million populations are live with iodine deficiency (Nikšić, Kulić et al.). At least 350 million Africans are at risk of iodine deficiency (Pandav, et al., 2013). In Ethiopia more than 35 million people are at risk of iodine deficiency (Shawel, et al., 2010).

2.6. Iodine Deficiency Disorder (IDD)

All adverse consequences of iodine deficiency are collectively known as IDD (Iodine Deficiency Disorders). Around the world every year, 40 million new borne are not yet protected against IDD (Tyan, 2010). Sixty million people are at risk of iodine deficiency disorder in the African continent alone, thirty million have goiter and 0.5 million suffer from crentism (WHO,2008).In India an estimated 350 million people are at risk of IDD as they consume salt with inadequate iodine. Every year nine million pregnant women and eight million new born are at risk of IDD in India (Pandav, et al., 2013). Of the total population, 26% have goiter and risk of IDD according to national survey made by the previous Ethiopian Nutrition Institute.

2.7. Iodized salt

WHO estimate that 54 countries out of 126 still have inadequate iodine nutrition and 23 million babies each year globally are still born with inadequate iodine nutrition mostly in the poorest and economically least developed areas (Zimmermann, 2003). Ahmed and his colleagues study in India indicated that 42% household salt samples were having iodine content less than 15 ppm, so they are at risk of developing IDD and around 4% households sample that contain no iodine are highly susceptible to IDD (Iodine Deficiency Disorders) (Fairweather-Tait and Hurrell, 1996).

According to Ethiopia Demographic and Health Survey in 2011(EDHS), only 15.4 percent of the households were using iodized salt. Other study on neighboring country reported that less than 20% of coverage in Ethiopia household (Mahfouz, et al., 2012).

There is no universal specification for the level of iodine to be added to salt to achieve recommended intakes of iodine. Until recently, the level of iodine to be added to salt for a given population was determined on the basis of the severity IDD, average per capita salt consumption and anticipated losses of iodine during distribution. Specifically, based on their earlier experience WHO, 1990, Recommended that the level be based on the assumption of 50% iodine loss between iodization and consumption. ICCIDD/WHO/ UNICEF have described desirable average levels of iodine in salt at various points in the salt distribution chain, taking into account level of salt intake, climatic conditions and packaging. As an example, based on ICCIDD/WHO/UNICEF recommendations to achieve the required iodine addition level for persons with daily salt consumption of 10g, 25ug, iodine is required per gram of salt at the point of consumption. In a warm, humid climate, with an expected loss of 50% during transport and storage, this would require the addition of 50ug of iodine at the iodization facility (Diosady, et al., 1998).

Typical iodization levels vary from 30 to 100ug iodine per gram of salt (Diosady,et al., 1998).The Ethiopian Standard specifies 60-80 mg/kg.

2.8. Factor Affecting consumption Iodized salt

There are many factors that affect consumption of iodized salt in the population. The finding reported by Baguune and Buxton in Ghana indicated that 26.8% of the respondents used both common and iodized salt, partly due to the shortage of iodized salt on the market at certain times, other indicate that they were unable to distinguish between iodized salt from that of common salt sold on the markets and some others indicate that iodized salt is more expensive than common salt (Buxton and Baguune, 2012). Study in India points out that iodized salt has five times higher cost than from common salt and regarding reasons of occasional or never use of iodized salt in Pakistan, majority of the respondents mentioned its price (31.4%-31%) and unavailability (42% and 25%) in the area this influence decision to use common salt . The survey also revealed a high level of knowledge about iodized salt (85%) but low level of use due to its high price (31%), unavailability (25%) misconception (7%) (Khan, et al., 2013).

Study in Turkey showed similar findings that use of local mass media is effective in raising the prevalence of iodized salt use. According to Tyan study the most proximal and obvious barrier to poor iodine intake is highly limited access to iodized salt, In addition study revealed that in examining WHO regions and the overall access to iodized salt, there appears to be strong positive correlation between the proportion having access to iodized salt and the percentage of its population receiving adequate iodine nutrition (Schubert, 2004). In Tanzania study reported that price (35%)), taste (35%), packaging (29%) and availability (5%) as the factors that determine their choice of salt (Kulwa and Leo ,2006).

2.9. Salt Fortification

Worldwide, 34 countries have eliminated iodine deficiency disorders through salt iodization (USI) (Mahfouz, et al., 2012). Universal Salt Iodization is the effective, safe, sustainable and cost effective intervention strategy for prevention, control and elimination of iodine deficiency Consistent monitoring of iodized salt production, storage, transportation and consumption level; and prevention of safe of non iodated salt are key components of salt iodization program.

Over the past century, many food vehicles have been fortified with iodine: bread, milk, water and salt. Salt is the most commonly used vehicle .USI was chosen as the best strategy based on the following facts: (Organization, 2008) salt consumption is fairly stable through the year; ii)salt is one of the few commodities consumed by everyone ;iii) salt production is usually in the hands of few producers; iv) salt iodization technology is easy to implement and available at a reasonable cost (0.4 to 0.5 US cents/Kg ,or 2 to 9 US cents per person/year);v)the addition of iodine to salt does not affect its color, taste or odor .vi) the quality of iodized salt can be monitored at the production, retail and household levels; and vii) salt iodization programmes are easy to implement (Buxton and Baguune, 2012).

There are two forms of iodine in iodized salt: iodide and iodate usually as the potassium salt, both are generally referred to as iodized salt. Iodate is recommended as the preferred fortificant because it is much more stable (Tyan, 2010). In Ethiopia Salt iodized with potassium iodate (KIO_3) by using wet method at level of 66 g KIO_3/ton of salt (FMoH, 2010).

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Table 1: Percentage of households using iodized salt over the last decade, by region.

	2007	2006	2003	2000	1997
Sub-Saharan	67	64	67	62	47
Eastern and southern Africa	60	60	-	-	-
West and Central Africa	73	68	-	-	-
Middle East and North Africa	65	58	53	48	75
South Asia	54	49	53	65	58
East Asia and Pacific	85	85	80	74	48
Latin America and Caribbean	86	86	81	89	80
CEE/CIS	50	47	39	25	26
Developing Countries	71	69	68	68	55
Least Developed Countries	53	53	54	57	33
World	70	68	67	66	54

Source: UNICEF Report, 2007

2.10. Source of heavy metal in the saline water body

A wide range of contaminants are continuously introduced into the aquatic environment naturally through weathering of the earth crust. The main natural source of heavy metals in water is weathering of minerals. Besides their natural occurrence, heavy metals may enter the ecological system through human activities. The aquatic systems receive a large amount of heavy metals from natural occurring deposits and natural processes and anthropogenic activities (Wogu and Okaka, 2011).

Heavy metals is a general collective term, which applies to the group of metals and metalloids with atomic density greater than 4 g/cm^3,or 5 times or more, greater than water (Duruibe, et al., 2007).However, being heavy metals has little to do with density, but concerns chemical properties. Commonly the term heavy metals are used to refer to elements that are associated with pollution and toxicity problems. It includes Lead, Cadmium, Zinc, Mercury, Silver, Chromium, Copper, Iron and Platinum group elements (Abbas ,2013).Elements like Mercury, Lead, Cadmium and Arsenic are the most toxic heavy elements even in trace amount and considered as non-essential whereas, Copper, Zinc and Iron are essential for humans; they play important roles in biological systems. When their intake exceeds the levels, they make harmful and toxic effects (Chen, 2012).

Edible salts can be contaminated to heavy metals since the saline lake receive a large amount of heavy metals from natural occurring deposits and natural processes and anthropogenic activities some studies of heavy metals in salt had previously been conducted in Ethiopia , Iran etc (Ovji, 1994; Binega ,2006).

2.11. Biochemistry of heavy metals toxicity

Essential metals are used either an electron donor system or function as ligands in complex enzymatic compounds. These trace elements are only used in trace amount by an organism and they are usually found in small concentration in the environment. The amount of heavy metals in the organism does not exceed the level which allows enzyme system to function without interference. The excess amount of heavy metals in the organism can be regulated by homeostasis. But, if the heavy metals concentration at the source of supply such as water and food or food additives is too high the homeostasis mechanism ceases to function and the essential heavy metals act either an acutely or chronically toxic manner (Javed and Usmani ,2011).

On absorption, the pollutant is carried in blood stream to either a storage point or to the liver for transportation or storage. Pollutants transformed in the liver may be stored there or excreted in bile or transported to the other excretory organs for elimination or stored in fat which is an extra hepatic tissue (Obasohan, 2007). The poisoning effects of heavy metals are due to their interference with the normal body bio chemistry in the normal metabolic processes. When ingested, in the acid medium of the stomach, they are converted to their stable oxidation states (Zn^{+2},Pb^{+2},Cd^{+2},As^{+2},As^{+3},$Hg^{+2}$and Ag^{+}) and combine with the body's biomolecules such as proteins and enzymes to form strong and stable chemical bonds (Duruibe, et al., 2007).

The hydrogen atoms or the metal groups are replaced by the poisoning metal and the enzyme is thus, inhibited from functioning, whereas the protein-metal compounds acts as a substrate and reacts with a metabolic enzyme. If the body utilizes the product formed from the heavy metal-protein substrate, there will be a permanent blockage of the enzyme, which initiate any other bio-dysfunctions of various gravities biomolecules, like proteins and enzymes to form stable bio toxic compounds, thereby mutilating their structures and hindering them from the reactions of their functions (Duruibe, et al., 2007).

Furthermore, a metal ion in the body's metallo-enzyme can be conveniently replaced by another metal ion of similar size. Thus Cd can replace Zn in some dehydrogenating enzymes, leading to cadmium toxicity. In the process of inhibition, the structure of protein can be mutilated to a bio-inactive form, and in the case of an enzyme can be completely destroyed (Duruibe, et al., 2007). For instance, lead has been observed to interfere with the calcium dependent release of neuro-transmitters. Also lead, cadmium and vitamin D have been shown to have a complex relationship affecting mineralization of bone and there exists a more direct influence involving impairment of 1-25 dihydroxy vitamin D synthesis in the kidney (Goyer and Clarkson ,1996).

2.12. Food Safety

Chemicals hazards in food are potentially toxic substances that either occur naturally, such as heavy metals and marine toxin, or manmade. Manmade chemicals can be added to food intentionally, such as preservatives and colorants, they may be present as residue of pesticides and animal drugs or they can unintentionally contaminate food through the environment or through the production process, for example, metals, cleaning agents and packaging materials used to keep safe and fresh .Unintentional contamination may also occur through environmental pollution of the water, air, and or soil (Grandjean and Landrigan, 2006).

Infants and children are potentially more vulnerable to the effect of ingesting chemical hazards, owing to still developing organ systems and higher exposure. Children consume more food per unit of body weight than adults: in the case of infants, twice the amount. Moreover ,developing organs and tissues are more susceptible to the toxic effects of certain chemicals .For example excessive exposure to lead methyl mercury during gestation or early childhood may causes serious damage to the developing brain with consequent loss of intellectual potential ,while an adult experiencing the same exposure will suffer no great effect on his/her intellectual capacity. Symptoms related to prolonged low level exposure may not be apparent until later in life and ,when they do occur, may be chronic and irreversible .Serious illness due to long term exposure to various toxic chemicals may include damage to the immune and nervous system ,impairment of reproductive function and development ,congenital anomalies in the offspring, cancer ,and organ specific damage (Julvez and Grandjean ,2009).

Deadly diseases like edema of eyelids, tumor, congestion of nasal mucous membranes and pharynx, stuffiness of the head and malfunctions in genetic makeup, gastro intestinal cavity, muscular reproductive and neurological systems caused by heavy metals have been documented (John and Sunday, 2011).WHO estimates that about a quarter of the diseases facing man kinds today occur due to prolonged exposure to heavy metals. Most of those environment-related diseases are however, not easily detected and may be acquired childhood and manifested later in adulthood (Zeneli, et al., 2011).

2.13. National Codex Committee

Codex is an international body developing food standards play a major role in ensuring food safety by protecting contamination in all food chain, from farm to fork. The mandate of codex is to establish international food standards to protect the health of consumers and to ensure fair practices in the food trade, while promoting coordination of food standards work undertaken by international governmental and non- governmental organizations (Alemanno, 2015).According to the codex standard, food grade salt should not contain contaminants in amounts which result in a harmful health of consumers (2001). Since, ingredients or content of safe food or food additives including edible salts are placed in the standard as requirements, products with limits beyond the requirements of the standard can be removed or sanctioned by the government before they reach the consumers. Standards are set not only at final stage (end product) of the food, but also from the beginning .This is because food and food products get contaminated during manufacturing, storage, transportation, etc. If all of these are not properly regulated, it is not possible to say food is safe (Yalemtsehay, 2010).

2.14. The Ethiopian Standard Specification for both iodized Common and Table Salts

Characteristics	Iodized common salt	Iodized table salt	Test method
Chloride content			ES ISO 2481
(as NaCl), % (m/m)	96	98	
Iodine content, mg/kg,			ES ISO
-as potassium iodate	60-80	60-80	
-as iodine	36-48	36-80	
Loss of mass at 110^{o}C, % (m/m).	4	0.5	ES ISO 2483
Matter insoluble in water % (m/m).	1	0.2	ES ISO 2479
Calcium, % (m/m), water soluble.	-	0.5	ES ISO 2482
Magnesium, % (m/m) water soluble.	-	0.5	ES ISO 2482
Sulphate (as SO_4), %(m/m),max	0.5	0.5	ES ISO 2480
Alkalinity (as Na_2 CO_3), % (m/m), max.	0.2	0.2	ES 308

Table: 2 The Ethiopian Standard for both common salt and table salt.

Table 3-Contaminants in iodized common and table salt

Contaminant	Requirement	Test method
Lead	2 mg/kg	ES 309
Iron	10mg/kg	ES 310
Copper	2 mg/kg	ES 312

2.15. Risk assessment

Provisional Tolerable Weekly Intake is an endpoint used for food contaminants such as heavy metals with cumulative properties. Its value represents permissible human weekly exposure to those contaminants unavoidably associated with the consumption of otherwise wholesome and nutritious foods. Provisional Tolerable Weekly Intakes (PTWI) is set for substances, such as heavy metals, that are contaminants in food are known to accumulate in animals and humans. Like in other organisms, heavy metals are not destroyed by humans. Instead, they tend to accumulate in the body and can be stored in soft and hard tissue such as liver, muscles and bone and threaten the health of humans (Edlin, et al., 2000). Study conducted in Iran by (Eftekhari, et al., 2014) estimate the daily heavy metals intake and their associated risks were determined using the following calculation:

Daily intake of heavy metals = concentration of heavy metals in the salts × mean salt intake (g/person/day)

Weekly intake of heavy metals = daily intake × seven days/week

2.16. Selected heavy metals in salt

2.16.1. Cadmium

Cadmium is a natural element which originates from water, sediments and food and may accumulate in the human body (Pan, et al., 2010). A report in Iran the cadmium content of recrystalized and washed table salt samples were found 0.02µg/g and 0.017µg/g, respectively (Eftekhari, et al., 2014). Cd is highly toxic and responsible for several cases of poisoning through food. Small quantities of Cd cause adverse changes in the arteries of human kidney. It replaces zinc biochemically and causes high blood pressures and kidney damage (Salano, 2014). In the study by Soylak the amount of cadmium was 0.014-0.030µg/g in both refined and unrefined table salt samples from Turkey, Egypt and Greece (2008).Cadmium is widely known to be a highly toxic non- essential heavy metal and it does not have a biological role in living organisms. Thus ,even at its low concentration, cadmium could be harmful to living organisms (Tiimub and Afua, 2013).In a survey conducted in Tehran, showed that 0.91µg/g which is high amounts of cadmium which exceed the limit set by WHO in edible salt (Kahaniki,et al.,2007). Excess Cadmium induce kidney dysfunction, skeletal damage, reproductive deficiency, carcinogenic, teratogenic, genotoxic, damage to the central nervous system and produce psychological disorder (Akoto, et al., 2014).

2.16.2. Lead

According to Agency for Toxic Substances and Disease Registry (ATSDR, 2005) Lead is the second to Arsenic leading toxic heavy metals. Weathering, flaking and dust are natural sources. Lead is considered as a toxic even at low concentration and non- essential metal implying that it has no known function in the biochemical processes (Akoto, et al., 2014).

Children are particularly susceptible to lead exposure due to high gastro intestinal uptake and the permeable blood–brain barrier (Fu and Yang, 2005). The concentration range of lead in the refined and unrefined table salts investigated in Iran was 0.50–1.64 µg/g the highest level of lead was found in Becel salt whereas the lowest level was in Kalas salt from Greece. Lead concentrations of table salts from Brazil were reported in the range of 0.03–0.10 µg/g by (Amorim and Ferreira, 2005). A report from Iran, Isfahan showed that the Lead concentration in table salt samples were 2.728µg/g which is above the limit set by codex legislation (Zarei, et al., 2011). Lead has a negative influence on both children and adults. For children, Pb reduces the physical and mental growth (Simeonov, et al., 2010). The intelligent quotient of children is diminished and symptoms of irritability and fatigue could be observed. In the literature from Tehran, Lead content in the salt samples were 0.87µ/g (Khaniki, et al., 2007). Pregnant women exposed to Pb have higher rates of infertility, miscarriage and still births (Edlin, et al., 2000). Chronic exposure to Pb can affect physical growth and can cause anemia, kidney damage, headache, hearing problems, speaking problems, fatigue or irritable mood (Simeonov, et al., 2010). In refined and unrefined table salt samples from Brazil was found to be 0.03µg/g (Amorim and Ferreira, 2005). The toxicity of Pb is multiple biochemical effects. It has the ability to inactivate enzymes, compete with calcium for incorporation into bones and interfere with nerve transmission and brain development (Edlin, et al., 2000).0.8mg/kg of lead were found in table salts from Nigeria, Which exceed the standard set by codex legislation (Usman and Filli, 2013).

2.16.3. Zinc

Zinc is an essential element at low concentrations, but in excessive levels, it has potential hazards to human health. Literature from Isfahan reported that the zinc content in the salt was 6.34 μg/g (Khaniki, et al., 2007). Zinc toxicity is rare but at concentrations of up to 40 mg/kg, it may induce toxicity characterized by symptoms of irritability, muscular stiffness and pain (Al-Weher ,2008). Another study in Tehran reported the Zinc content of edible salt was found to be 6.5μg/g (Pourgheysari, et al., 2012).

The average adult body contains between 2-3 g of zinc. Zinc is used to form connective tissues like ligaments and tendons (Miculescu, et al., 2011).In a study conducted in Shiraz reported that the concentration of zinc was 0.34 μg/g in recrystalized and 0.37 μg/g in washed samples.

2.16.4. Copper

The permitted level of copper in food grade salt is 2.0μg/g (Usman and Filli, 2013). At low concentration, copper is essential for human healthy, although high level of this element is toxic. Copper content in salt from Tehran reported to be 1.21μg/g (Khaniki, et al., 2007). Despite the positive effects of optimal levels of copper, harmful effects may occur if a threshold level is exceeded. Literature from Nigeria reported the copper content of table salts is found to be 3.95mg/kg which exceed WHO recommendation (Usman and Filli ,2013).

Wilson's disease (hepatolenticularic degeneration) is one of the diseases linked to the excess of copper in the body. It results from a dysfunction of the copper transmission process, which occurs due to a lack of suitable enzyme to catalyze the process of copper deletion from detached bonds with albumins and binding to ceruloplasma. The condition leads to neuron degradation, liver cirrhosis, and occurrence of colorful rings on the cornea (DiDonato and Sarkar, 1997).

2.16.5. Magnesium

The Magnesium content of all the salt samples analyzed in Nigeria were found to be with the recommended quantity of 3.0g/kg (Usman and Filli, 2013).

Mg is associated with abnormal irritability of muscle and convulsions and excess Mg with depression of the central nervous system (Budavari ,1997).Recrystalization of salt remove 80-90 % of magnesium (Attique and Muhammad, 2010). Magnesium increase moisture content of the salt (Kelly, 1953).

2.16.6. Iron

Iron is an absolute requirement for most forms of life, including humans. Iron ranged from 0.90-3.95 mg/kg in different salts which are produced in Nigeria .In the nineteenth century, iron was discovered to be a necessary part of hemoglobin in the red blood cells that transport oxygen and carbon dioxide in the body (Haidar, 2010). 0.689 µg/g of iron reported from table salt Hamadan. Iron can also be potentially toxic. Its ability to donate and accept electrons means that if iron is free within the cell, it can catalyze the conversion of hydrogen peroxide into free radicals. Free radicals can cause damage to a wide variety of cellular structures, and ultimately kill the cell (Moreno, et al., 1992). 8.75 µg/g of iron found in edible salt produced in Iran (Ali, et al., 2014).

2.17. Sodium Chloride

According to (Kirabira, et al., 2013) the concentration of sodium chloride in salts which are processed in different methods such as evaporation, chemically treated and chemically treated along with filtration resulted in 75%, 95% and 97% respectively. The estimated minimum daily requirement of sodium chloride for healthy adults and children 10 years and older is 500 mg/day. At birth, the estimated minimum requirement ranges from 100 to 200mg/day and increases to 225 mg/day at 1 year of age. The minimum requirement increases throughout childhood to 400 mg/day at 9 years of age. Pregnancy and lactation increase the minimum requirement by 169 and 135 mg/day, respectively (Kuczmarski and Flegal, 2000). The kidneys have considerable flexibility in removing excess sodium and can accommodate intakes greater than the minimum requirements. Because sodium is a common constituent of food and water, diseases of sodium deficiency in humans are very rare. However, excess sodium intake can cause acute and long-term health effects (Kuczmarski and Flegal, 2000).

The chloride content (as NaCl) in the rock salt sampled from Assale is found to be 95.22 % (Binega, 2006). Acute effects and death have been reported in cases of accidental overdoses of sodium chloride. Acute effects may include dryness of mucous membranes, violent inflammatory reaction and ulceration in the gastrointestinal tract, along with dehydration and congestion of internal organs, particularly the meninges and brain. Central nervous system disturbances such as convulsions, confusion, and coma may result, and generalized and pulmonary edema are possible. Death may occur from respiratory failure secondary to an acute encephalopathy. Infants and children are somewhat more susceptible than adults to the effects of acute overdoses of sodium chloride because the kidneys of immature individuals are not as effective in controlling sodium levels as the kidneys of adults (WHO, 1979).

2.17. Alkalinity

Bicarbonate has a long history of use in foodstuff including edible salt, feed and industrial processes. The bicarbonate ion is a normal constituent in vertebrates, as the principal extracellular buffer in the blood and interstitial fluid is the bicarbonate buffer system (UNEP, 1995). The alkalinity of edible salt which are processed in different methods in Uganda showed 1.3%, 1% and 0.1298 % respectively (Kirabira, et al., 2013).

There have been a number of cases where excessive ingestion has caused moderate to severe toxic effects. The most prevalent symptoms are excessive carbon dioxide production, metabolic alkalosis, and cyanosis (Brown, et al., 1981). (Binega, 2006) found high amount of alkalinity in the rock salt in Ethiopia 1.39 %which exceeds the standard set by the ES. Absorption of $NaHCO_3$ is known to cause alkalosis (AL-Saffar, et al., 2012). The acid-base disturbance is usually transient in individuals with normal renal function, as the base excess will rapidly be excreted. The urinary pH can, however, be elevated affecting tubular reabsorption and urinary elimination of weak acids and bases (AL-Saffar, et al., 2012). The minimum dose causing adverse effects will vary strongly according to age and health condition (Jaeger, et al., 1987).

2.18. Sulphate

Sulphate generally present in the salt as impurity and does not cause any health problem ,but high concentration acts as a purgative (Kumar, 2001). (Binega 2006) reported that the sulphate content of salt in Assale 0.09% which is below the limit set by the ES. 2.5%, of sulphate in the salt were found in Uganda by (Kirabira, et al., 2013). Excess consumption of sulphate result in cathartic effects, due to purgation of the alimentary canal (Müller-Lissner, 2005). However, with time human appear to be able to adapt to higher sulphate concentrations. Dehydration has also been reported as a common side effect following the ingestion of large amounts of sulphate (Müller-Lissner,2005).

2.19. Moisture content

The stability of iodine in salt is determined by the moisture content of the salt (Kelly 1953). The salt is not washed or ground, and it has a milky-white color. Its moisture content is 1% during the dry season but 3–4% during the damp season (Zimmermann, et al., 2004). Magnesium on the surface of the salt crystal absorbs humidity from the air and makes the salt damp (Sedivy ,1996).

2.20. Matter insolubility

Salts which are obtained by solar evaporation in Uganda contain 2.5 % insoluble matter (Kirabira, 2013) .For salt with contaminants not exceeding 0.02 % in soluble matter (Diosady, et al., 1997). (Kirabira,2013) reported 0.001% of insoluble matter in salt which processed chemically. A comprehensive review of the literature by Kelly reported that the stability of iodine in the salt is determined by the amount of insoluble matter found in the salt (Kelly, 1953).

2.21. pH of the salt

PH determines the contents of impurities and the stability of iodine in the salt (Kelly, 1953).The pH of the solution of rock salt sample from Ethiopia was found to be 6.03 (Binega, 2006).

2.22. Metal analysis

Direct determinations of trace metal ions in edible salt samples by flame atomic absorption spect rometry are difficult. Because sodium chloride is a bulk matrix and some metals have a concent ration in milligram per liter and microgram per liter range which is near or below the limit of detection of method. Separation pre concentration methods including solid phase extraction, solvent extraction, membrane filtration, cloud point extraction etc. can solve these problems (Dogan, 2001).

Most metals determination is for detecting trace quantities. These are determined by various spectroscopic or chromatographic methods, such as : atomic absorbance spectrometry using flame (FAAS) or graphite furnace (GFAAS) Atomization, Atomic emission spectrometry

(AES),inductively coupled plasma atomic emission spectrometry (ICP-MS),X-ray fluorescence (XRF),and ion chromatography(IC) (De Souza, et al., 2013).

Preparation of materials for determination of metal content serves several purposes, which vary with type of sample and the demands of the particular analysis. Some of the major functions of sample preparation are ;to degrade and solubilize the matrix, to release all metals for analysis; to extract metals from the sample matrix into a solvent more suited to the analytical method to be used; to concentrate metals present at very low levels to bring them into a concentration range suitable for analysis; to separate a single analyte or group of analytes from other species that might interfere in the analysis; to dilute the matrix sufficiently so that the effect of the matrix on the analysis will be constant and measurable; to separate different chemicals forms of the analytes for individual determination of the species present. The major concerns in selection of samples preparation methods for metal analysis are the analytical method to be used, the concentration range of the analyte, and the type of matrix in which the analyte exists (De Souza, et al., 2013).

Samples to be analyzed for elemental metal content are usually prepared by digesting the matrix in the case of organic matrix. An oxidizing mixture is used to destroy the entire organic matrix and solubilize the sample. This yields a clear solution containing the metals for analysis by such techniques as AAS, ICP, or ICP-MS. Nitric acid is commonly used, because there is no chance of forming insoluble salts as might happen with HCl or H_2SO_4. Hydrogen peroxide may be added to increase the oxidizing power of the digestion solution (Koffie, et al., 2014). In this study nitric acid and Flame Atomic Absorption Spectroscopy (FAAS) was used to determine the concentration of heavy metals and metal impurities.

3. Materials and Method

3.1. Sampling Areas

The study samples were collected from eight producers and re-processors found at different parts of the country. Namely; Shewit located at Tigray, Afderea, Tesfaye, Yemane, Ezana and Dobi located at Afdera, Yosis at Adama (Nazret), Taffo at Taffo, Addis Ababa, and M.Amole at Debrezyet (Bisheftu).

3.2. Coding of salt samples

Names of the sample	Code of the samples
Taffo	1
M.Amole	2
Shewit	3
Yosis	4
Ezana	5
Tesfaye	6
Yemane	7
Dobi	8

Table 4: coding of salt samples

3.3. Sampling and Sampling Procedure

Salt samples were collected from eight salt producers and re-processors found at different parts of the country. Samples at each site were replicated three times for all analysis using polyethylene sampling bag.

3.3.1. Method of Sampling

Composite sampling was used, in which the samples collected randomly from different locations were combined to be used for analyses.

3.3.2. Study Setting

The experiment was conducted in Food Science and Nutrition Research Laboratory, of Addis Ababa University, EFMHACA (Ethiopian Food, Medicine and Health care, Administration and

Control Agency) Laboratory, Laboratory of Department of Chemistry, and Laboratory of Environmental Science at Addis Ababa University.

3.4. Chemical analysis

All chemicals were of analytical grade and all glassware were soaked overnight in 10 %(v/v) nitric acid, rinsed with distilled water for about three times and dried before used. The samples were titrated to determine their iodine, sodium chloride and alkalinity contents. For sulphate determination gravimetric method was used and for moisture determination oven were used based on the procedure set by Ethiopian Standard in 2013.Flame Atomic Absorption Spectrophotometer, were used for analysis of heavy metals and metal impurities in salt samples (Cheraghali, et al., 2010).

3.5. Reagent and standard solution

All the chemicals used were of analytical grade. De-ionized water was used for all dilution and rinsing purposes throughout the study. Sodium thiosulphate, concentrated sulphuric acid, potassium iodide, soluble chemical starch were used for iodine determination. Hydrochloric acid, methyl orange, were used for alkalinity. Nitric acid was used for digestion of salt sample for heavy metals and metal impurities.

3.6. Determination of moisture content

Moisture content was determined by oven drying method following the procedure (AOAC1998). Empty dishes were dried using air drying oven for an hour at 105^{o}C, transferred to the desiccators ,cooled for 30 minutes ,and was weighed .The samples were mixed thoroughly and the homogenized salt samples was transferred to the dried and weighed crucible. The crucible and its content were kept in the drying oven and dried for 3 hours at 110^{o}C and then the crucible and their contents were cooled in desiccators to room temperature and weighed.

3.7. Determination of Alkalinity

Alkalinity as Sodium carbonate was determined by (AOAC 1998).Washed the flask with carbon dioxide free distilled water. About 20g of sample salt was weighed and dissolved in one liter of double de-ionized water and filtered the solution then, the residue was discarded and 50ml of the filtrate was titrated against 0.1N Hydrochloric acid using methyl orange as an indicator.

3.8. Determination of sulphate

About100 gm of salt sample dissolved in 1000ml of distilled water then 2.0 ml of Hydrochloric acid solution, heated to boiling with continued stirring 10ml of the barium chloride solution was added drop by drop and left it in boiling water bath for 1h.

The precipitate was filtered through an ashless filter paper, and washed with boiling water. Because, chloride ions were detected when silver solution was added to the filtrate .The residue was washed over and over again until no more white precipitate was formed on testing of the drop of the filtrate with silver nitrate solution. The filter paper and its content in the crucible were placed in an oven at 110^{o}C until completely dried. Then, the filter papers were ignited in the electric furnace at 825^{o}C, cooled in the desiccator, and weighted.

3.9. Determination of sodium chloride

About 250 mg of previously dried salt at 625^{o}C for 2h dissolved in 50 ml of distilled water in glass stoppered flask. Then 3ml nitric acid, 5ml of nitrobenzene, 50ml of silver nitrate and 2ml of ferric ammonium sulphate as an indicator were added and shaken well. The excess silver nitrate was titrated against 0.1 N ammonium thiocyanate.

3.10. Determination of pH

About 20 gm of salt sample was dissolved in 100 ml distilled water and measured using Jenway3345 pH meter. Calibration was set between 4 and 10.

3.11. Determination of matter insoluble in water

About 100gm of the salt sample dissolved in 350 ml of distilled water and heated below boiling for 10 minutes with stirring and the beaker containing the solution was kept in a boiling water bath for 30 minutes. Filtered by vacuum on the filter crucible which was previously dried at 110 ^{o}C and cooled in the desiccators & weighed. Then, the insoluble matter was washed successively using distilled water in order to bring the insoluble matter into suspension for approximately one minute before filtered, and after repeated washing silver nitrate solution was added to the filtrate to check the presence for chloride ion. Finally, the crucible and its contents were dried in the oven at112^{0}C, and weighed.

3.12. Apparatus for iodine titration and Determination of iodine

Laboratory balance, gas burner, small stainless bowel, 250 ml and 1000 ml glass bottles with stopper, measuring cylinder with stopper 100 ml ,wash bottle,250 ml glass stirring rod, glass or plastic funnel 300 ml pipettes 1 ml and 5 ml, burette,10 ml and stand ,volumetric flask 500 ml clock and a closed box were used.

3.12.1. Preparation of reagents

About 1.24 grams $Na_2S_2O.5H_2O$ in 1000 ml was dissolved in 1000 ml boiled distilled water to prepare 0.005M sodium thiosulphate. H_2SO_4 was prepared by slowly adding 6ml concentrated sulfuric acid to 90 ml double distilled water and marked up by distilled water to 100 ml. KI was prepared by dissolving 10 g potassium iodide in 100 ml double distilled water. A reagent grade sodium chloride was dissolved in 100 ml of distilled water until no more sodium chloride dissolved. More Sodium chloride was added and the solution was heated in the beaker. While cooling, the NaCl crystal was left on the sides of beaker. When it was completely cooled the supernatant were decanted into a starch solution which contains 1 gm of starch dissolved in 10 ml distilled water in order to make 100 ml of starch solution.

3.12.2. Procedure for iodine determination in salt samples

About 10 grams of the salt sample was weighed and dissolved in boiled double de-ionized water in 250 ml conical flask, one ml of 2N Sulfuric acid and 5 ml of 10% potassium iodide was added into the salt solution .The salt solution turned yellow and kept in the dark for ten minutes. After ten minutes the salt solution titrated with sodium thiosulphate and immediately stopped when the solution turned light yellow then, few drops of 1% starch solution were added and turned the solution deep purple and continued titration until the purple coloration disappeared. The volume of sodiumthio sulphate in the burette multiplied by 10.6 in order to determined the amount of iodine in the salt samples.

3.13. Determination of metal impurities

About 20 g of salt sample were dissolved and dilute in 100 ml of double-distilled purified water in a 250 ml polyethylene flask. After adjusting pH to 4.4-4.8 using acetic acid-sodium acetate buffer, 5 ml of APDC (Ammonium Pyrolidine Dicarbamate) added. Following five minutes of intense shaking of the mixture, organic phase separated and its absorbance measured using FAAS (Cheraghali, 2010).

3.13.1. Analysis of metals

Concentration of Zn, Pb, Cd, Mg, Ca, Fe and Cu were determined in salt samples. The analysis of heavy metals in salt was carried out by Flame Atomic Absorption Spectrophotometer was used for determinations. The operating conditions for Zn, Pb, Cd, Mg, Ca, Fe and Cu analysis by FAAS were set accordingly. Calibration of the instrument was carried out with a range of standard solution.

Validation of analytical methodology (Recovery test)

The digestion method and FAAS analysis were validated by measuring the recovery of Zn, Pb, Cd, Mg, Ca, Fe and Cu spiked to salt samples. The known volume and concentration of standard solution were employed on the samples in order to determine recovery. The volume of 1.5 ml for Zn, Pb, Cu, Ca Mg, Fe and Cd was added to 1gm of salt. The spiked sample was then digested in the same way as salt sample. The final volume of the digestion was diluted to 50ml and run on FAAS and metal contents determined from the calibration curve.

The amount of spiked metals recovered after the digestion of spiked samples was used to calculate percentage recovery using (Burns, et al., 2002) formula.

$$\text{Recovery}=\frac{\text{Conc.Spiked sample} - \text{un spiked sample}}{\text{Conc.Analyte added (spiked)}} \times 100\%$$

The recovery percentages of spiked salt sample were obtained for metals under investigation varied between 94.6% and 100%.The results are in acceptable range which is mostly no less than 70% and no greater than 125% (Machado and Griffith, 2005) and which revealed that the digestion method and the FAAS analysis were reliable.

Detection limit

Method detection limit (MDL) is defined as the minimum concentration of analyte that can be identified ,measured and reported with 99% confidence that the analyte concentration greater than zero ,and is determined from analysis of a sample in a given matrix containing the analyte (USEPA,1997).

Method detection limit for salt samples was established using the blank reagents HNO_3 which was used to digest the salt samples. Seven replicate blanks were digested in the same condition as salt sample. The method detection limits were calculated according to (Childress, et al., 1999) formula:

$$MDL=(S) \times (t)$$

Where: MDL= Method Detection Limit

S =standard deviation of the seven replicate analysis

t= students value for 99% confidence level and standard deviation estimated with n-1 degree of freedom

The concentrations of the metals in salt samples below MDLs were rejected and only above MDLs were reported in this study.

Concentration of Zn, Pb, Cd, Mg, Ca, Fe and Cu were determined in salt samples. The analysis of heavy metals in salt was carried out by Flame Atomic Absorption Spectrometer was used for determinations. Calibration of the instrument was carried out with a range 0.25-4ppm of standard solution. The samples were analyzed in duplicates, and the blank determinations in duplicates were also run in the same manner during the analysis.

3.13.2. Calibration procedure

The analyses of heavy metals in metal impurities in the salt samples were carried out by Flame Atomic Absorption Spectrometry model ZEEnit 700P. Calibration of the instrument was carried out with range of standard solution.

Calibration curves for each heavy metal were set to ensure the accuracy of the atomic absorption spectrometry and to confirm that the results were true and reliable. The calibration of Flame Atomic Absorption Spectrometry was made with standard solutions. Calibration standards were prepared by serial dilution of concentrated stock solution of 1000mg/L for cadmium, lead, zinc, copper, magnesium, calcium and iron. These solutions and blank were aspirated into FAAS. A calibration curve of absorbance Vs concentration was established for each metal and used for determination of metal concentration in the salt samples. The calibration curve of each metal was given in appendix 1.

3.14. Statistical analysis

All the data obtained during laboratory studies were analyzed with analysis of variance (ANOVA).The data were recorded as Mean ± SD. When values ($P \leq 0.05$) were found significant the means of each parameter were compared using the least significant differences (LSD) procedures of SPSS, version 15.

4. RESULT AND DISCUSSION

4.1. Iodine content of eight edible salt samples

The mean and standard deviations of iodine content of eight salt samples is presented in Table 5.The table shows that the mean iodine content of sample 6 (71.6ppm) which is from Afdera is significantly higher than samples 1, 2,3,4,5, 7 and 8.

Table 5- Content of Iodine (ppm) in eight selected edible salt samples in Ethiopia

1	58.99 ± 3.21^{b}
2	51.94 ± 4.85^{c}
3	23.67 ± 1.61^{d}
4	13.07 ± 0.66^{e}
5	25.44 ± 1.06^{d}
6	71.76 ± 8.09^{a}
7	23.32 ± 1.06^{d}
8	4.240 ± 1.06^{f}

$^{a-v}$ values with different superscripts with the column were significantly different at ($p \leq 0.05$).

Iodine content is one of the most important mineral required in salt. There is a serious campaign on salt iodization in Ethiopia all salts that are sold in the markets are expected to be iodized. Ethiopia had set the legal frame work in 2011 which impose legal obligation on producers, distributers, importers and all individuals involved in salt trade to ensure the salt for human consumption is adequately iodized (EFHMAC,2011).

Table 6 results of Iodine, essential composition and quality factors for both common and table salt samples collected from eight producers and re-packers found in Ethiopia.

Quality	1	2	3	4	5	6	7	8	ES/Codex
Iodine ppm	58.99	51.94	23.67	13.07	25.44	71.76	23.32	4.24	60-80
Sodium chloride m/m	98.03	98.18	96.13	98.16	96.60	96.81	96.8	98.5	96-98
Loss of mass m/m %	0.23	0.20	2.66	1.26	1.20	0.46	2.66	2.06	0.5-4
Matter insolubility m/m%	0.73	0.18	0.45	0.48	1.26	1.63	2.00	2.163	0.2-1
Sulphate m/m%	5.15	0.13	0.32	0.24	0.21	0.51	0.47	5.13	0.5
Alkalinity m/m%	0.27	0.16	0.28	0.12	0.47	0.28	0.95	0.56	0.2
pH	8.54	8.56	7.93	8.40	7.85	8.25	8.32	8.75	8

The Ethiopian Standard (ES) specifies 60-80ppm of iodine content in salt at production site. But, the result in table: 6 show that only one salt sample confirms the specification, the rest of the results are below the standard. This might be due to little attention has given in the iodization process and other qualities of the salt such as magnesium and moisture also affects the iodine which was added in the salt. The result agrees with the finding in Nigeria which were ranged 0 - 74.1 ppm (Usman and Filli 2013). (Hurlbut, 1985) also reported iodine content of salt 42ppm in America.

The eight salt samples which were collected for analysis shows the above result in table 7. The samples were analyzed for their sodium chloride, loss of mass, Matter insolubility, alkalinity, sulphate and pH.

Table -7 Essential compositions and quality factors for iodized common and table salts.

Salt code	Sodium chloride	Loss of mass	Matter insolubility	Sulphate	Alkalinity	PH
1	98.03±0.219[a]	0.23±0.05[d]	0.73±0.11[c]	5.15±0.79[a]	0.27±0.04[a]	8.54±0.05[b]
2	98.11±0.340[a]	0.20±0.00[d]	0.18±0.01[d]	0.13±0.10[e]	0.16±0.01[a]	8.56±0.01[b]
3	96.01±0.248[c]	2.66±0.11[a]	0.45±0.03[d]	0.32±0.17[b]	0.28±0.03[a]	7.93±0.06[e]
4	98.16±0.045[a]	1.26±0.34[c]	0.48±0.03[d]	0.24±0.05[c]	0.12±0.07[a]	8.40±0.01[c]
5	96.16±0.348[b]	1.20±0.34[c]	1.26±0.20[b]	0.21±0.00[c]	0.47±0.07[a]	7.85±0.05[e]
6	96.81±0.337[b]	0.46±0.11[d]	1.63±0.25[b]	0.51±0.00[d]	0.28±0.03[a]	8.25±0.04[b]
7	96.8±0.3170[b]	2.66±0.11[a]	2.00±0.36[a]	0.47±0.13[d]	0.95±0.01[a]	8.32±0.02[c]
8	98.5±0.2940[a]	2.06±0.11[b]	2.16±0.38[a]	5.13±0.37[a]	0.56±0.03[a]	8.75±0.02[a]

[a-f]Any means in the same column not followed by the same latter are significantly different at ($p \leq 0.05$).

4.2. Sodium Chloride

Samples of common salts 5,6,7 and 8 and table salts 1,2, 3 and 4 were analyzed for sodium chloride. Amount of sodium chloride determines how concentrated the salt would be. The result in Table 7 shows that there were significant differences in salt concentration in the salt samples.

Table: 6 shows that out of the eight salt samples only one sample (3) does not meet the ES standard but, all the others salt samples meet the recommendation set by the Ethiopian Standard (ES).This might be due to poor production process.(Usman and Filli 2013) 96.5-99.86 % of sodium chloride was reported in table salts in Nigeria which agrees with this finding. The chloride content (as NaCl) in the rock salt sampled from Assale, Ethiopia is found to be 95.22 % (Binega, 2006). A study conducted in Pakistan indicated that recrystalization process improved the content of sodium chloride in rock salt from (91.84-94.18) to (98.28-98.86) (Attique and Muhammad, 1010).

4.3. Moisture Content

The ES specification for loss of mass % (m/m), is 4 for common salt and 0.5 for table salt respectively. Table: 7 shows that the moisture content of each salts were significantly different. Research in Morocco showed that the moisture content of salts were 1% during the dry season but 3–4% during the damp season (Zimmermann, et al., 2004). 0.549 % of moisture in edible salt was reported by (Blaurockbusch, 1996).

Table: 6 shows the moisture content for all the common salt samples 5, 6, 7 and 8 common salts from Afdera and Dobi fall within the specification set by ES. But, two of the table salt samples which were 3 and 4contain much more moisture than the standard set by ES. This is because these two re- processors did not use anti-caking agents as well as after washing they did not allowed the salt to dry. According to (Kelly, 1953) the stability of iodine in the salt is determined by the moisture content of the salt.

4.4. Matter insoluble in water

Table: 7 shows the Matter insoluble in water content obtained from analysis of edible salts samples. Contents of matter insoluble in water in edible salts samples were significantly different. This could be attributed to exposure to the sand. Proper care was not taken to prevent dust settling on the salt since, the producers assigned with production quota which exposed the production for sand particles and ashes for years.

The Ethiopian Specification specifies 0.5 mg/kg for matter insoluble in water. Table:6 shows that all the salt samples were failed to meet the ES, except (2) table salt. A comprehensive review of the literature by Kelly reported that the stability of iodine in the salt is determined by the amount of insoluble matter found in the salt (Kelly, 1953). (Usman and Fiili ,2014) reported a value of 1.299% water insoluble solid which falls within the same range as observed in this research. Salts which were obtained by solar evaporation in Uganda contain 2.5 % insoluble matter and 0.001% of insoluble matter in salt which processed chemically (Kirabira, et al., 2013).

4.5. Sulphate

The result in Table-7 shows the two samples which were 1 and 8 significantly different from the rest of the samples. According to geologist the lake of Afdera is the result of Quaternary eras intensive sedimentations .Therefore, huge amounts of sulphate is accumulated (Solomon, et al., 2011). ES specifies sulphate 0.5g/kg. Table : 6 shows Out of the whole samples only three of them 1,6 & 8 have sulphate which exceed the standard and other results agrees with the result of (zaszlo, 2001). Sulphate generally presents in the salt as impurity and do not cause any health problem, but high concentration acts as a purgative (Kumar, et al., 2001).

4.6. Alkalinity

Table: 7 shows the values of alkalinity of all the salt samples were not significantly different from each others. The alkalinity of salt which were processed in different methods in Uganda showed 1.3%, 1% and 0.1298 % respectively (Kirabira, et al., 2013). (Binega,2006) found high amount of alkalinity in the rock salt in Ethiopia 1.39 % which exceeds the standard set by the ES.

The ES specifies 0.2 mg/kg for alkalinity. Table: 6 shows only two of the samples were found to meet the standard, but the other salt samples did not meet the standard. There have been a number of cases where excessive ingestion has caused moderate to severe toxic effects. The most prevalent symptoms are excessive carbon dioxide production, metabolic alkalosis, and cyanosis (Brown, et al., 1981).Alkalinity in salt can be either reduced or removed by improving the production processes (Kelly,1953; Attique and Muhammad , 1010).

4.7.pH

Table: 7 shows the results of pH of the solution of edible salts were significantly different. The solution of the rock salt samples from the Assale in Ethiopia was found to be 6.03 (Binega, 2006).Table:6 shows the values of pH in eight of the samples and the standard. As shown in the table: 6 only two values of the samples 3 and 4 were within the ranges of African Standard. The African standard specifies the pH 7-8 (AOS, 2012).The pH determines the level of heavy metals in the brine (Attique and Muhammad, 2010). PH also determines the contents of impurities and the stability of iodine in the salt (Kelly, 1953)

4.8. Heavy metals

Table: 8Heavy metals concentration in eight edible salt samples produced in Ethiopia.

Salt code	Cadmium	Lead	Zinc	Copper
1	0.05±0.00[d]	0.07±0.00[g]	0.38±0.28[b]	0.07±0.00[c]
2	0.10±0.00[b]	0.22±0.00[b]	0.13±0.05[b]	0.07±0.00[a]
3	0.90±0.00[c]	0.24±0.00[a]	0.52±0.39[a]	0.07±0.00[a]
4	0.10±0.00[b]	0.10±0.00[a]	0.20±0.10[b]	0.09±0.00[b]
5	0.03±0.00[e]	0.03±0.00[d]	0.36±0.05[b]	0.07±0.00[a]
6	0.02±0.00[f]	0.13±0.00[e]	0.20±0.00[b]	0.08±0.00[b]
7	0.11±0.00[a]	0.11±0.00[f]	0.32±0.03[b]	0.09±0.00[b]
8	0.08±0.00[c]	0.19±0.06[c]	0.43±0.05[a]	0.09±0.01[a]

[a-g] Values with different subscripts within the same column were significantly different ($p \leq 0.05$).

Researchers reported the presence of trace elements in the salt (Haddy, 2006; Steinhauser et al., 2006). Determinations of trace metal ions in refined and non refined salts have been performed by various researchers around the world (El Ghawi and Al-Sadeq, 2006; Makhoni and Alemasova, 1992; Chimilenko and Baklanov, 2000; Boppel, 1976; Ali, 1999; Amorim and Ferreira 2005; sovylak, et al., 2003).

Table: 9 values of metal impurities

Metals	1	2	3	4	5	6	7	8	ES/Codex
Cadmium	0.05	0.10	0.04	0.10	0.03	0.02	0.11	0.08	0.5 mg/kg
Lead	0.07	0.22	0.24	0.10	0.03	0.13	0.11	0.19	2 mg/kg
Zinc	0.38	0.13	0.52	0.20	0.36	0.20	0.32	0.43	14mg/kg
Copper	0.07	0.07	0.07	0.09	0.07	0.08	0.09	0.09	2 mg/kg
Calcium	0.26	0.35	1.63	1.52	0.61	0.41	1.5	0.42	0.5g/kg
Magnesium	1.96	2.60	4.17	3.83	1.79	0.825	4.39	2.57	0.5g/kg
Iron	0.41	0.14	0.41	0.56	0.18	0.32	0.41	0.74	10g/kg

4.8.1. Cadmium

Table: 8 shows the heavy metals content obtained from analysis of edible salts samples. Contents of cadmium were significantly different among salt samples. even at its low concentration, cadmium could be harmful to living organisms (Tiimub and Afua 2013). Cadmium exposure induces bone damage, osteoporosis, and renal tubular dysfunction that lead to renal failure in long term (Eftekhari, et al., 2014). Cd is highly toxic and responsible for several cases of poisoning through food. Small quantities of Cd cause adverse changes in the arteries of human kidney. It replaces zinc biochemically and causes high blood pressures and kidney damage (Salano, 2014). In Brazil, the cadmium content of salts was 0.01-0.03mg/kg. In Iran the cadmium content was 0.024mg/kg (Cheraghali, et al., 2010). Another report in Iran indicated that cadmium content of recrystalized and washed table salt samples were found to be 0.02µg/g and 0.017µg/g, respectively (Eftekhari, Mazloomi et al. 2014). Table: 9shows the cadmium content of all the salt samples were below the maximum permitted level.

Codex specifies 0.5 mg/kg of cadmium in edible salts and all the samples were found below the standard.

4.8.2. Lead

Table: 8 shows that all the samples were significantly different from one another with respect to lead content. Lead is one of the most toxic heavy metals that accumulates in the body and data published in literature indicates that its excessive intake harm different systems and organs such as central and peripheral nervous system, gastrointestinal tract, muscles, kidneys, and hematopoietic system (Munoz, et al., 2005). In literature reported in Iran the lead content range between 0.430-1.520mg/kg (Ali, et al., 2014).In another report in Iran, lead concentration was found to be 2.728µg/g ranged 0.01-5.8µg/g (Cheraghali, et al., 2010). In a study from Tehran indicated that the edible salt samples lead content was 0.87 µg/g (Jahed, 2007) Table: 9 shows the results of lead concentration and ES. All the lead contents were below the standard. The maximum permitted level of lead in food grade salt is 2 mg/kg according to the ES and codex.

4.8.3. Zinc

Tables: 8 shows that all the Zinc concentration in the salt samples was not significantly different. Zinc is an essential element at low concentrations, but in excessive levels, it has potential hazards to both animals and human health (Engstrom, et al., 2012). (Peerawat, et al., 1998) 0.2mg/kg of zinc in salts were reported in Thailand. The amount of zinc in all samples was below the standard. (Onianawa, et al .,2001) reported that the levels of zinc in edible salt is 2.13 mg/kg. A study conducted in pakistan showed that the salt which was treated chemically contained zinc ranged 0.0006-0.0129 mg/kg (Attique and muhammed,2010).Tratment of the salt chemically reduce significant amount of Metals including zinc (Attique and muhammed,2010). Table: 9 also show all the result were lower than the permitted maximum for human consumption as prescribed by codex.

4.8.4. Copper

Table: 8 shows Copper content of all the salt samples were not significantly different. Copper is essential for good health, but its high intake leads to liver and kidney damage (Zarei, 2011). Table: 9 shows all the results of copper concentration and the ES. According to ES the maximum permitted level of copper in food grade salt is 2 mg/kg. All the result of the samples was below the permitted levels. Copper content was 0.17mg/kg - 0.47mg/kg in (Sovyalk, 2008) study. Literature from Nigeria reported that the copper content of table salts is found to be 3.95 mg/kg which exceed WHO recommendation (Usman and Filli 2013). Excess copper interferes with zinc, a mineral needed to make digestive enzymes. Too much copper also impairs thyroid activity and the functioning of the liver. The WHO suggests that 10-12 mg/kg per day may be the upper safe limit for consumption (Attique and muhammed,2010) reported that salts which were passed different processes contained copper which ranged 1.9841-19.48 mg/kg.

Metals such as calcium, iron and magnesium are required by organisms at low level and become toxic at some higher level (Zenebe, 2011).

Table-10 Metal Impurities in iodized common and iodized salt

Salt code	Calcium g/kg	Magnesium g/kg	Iron mg/kg
1	0.26±0.05^{f}	1.96±0.01^{d}	0.41±0.02^{c}
2	0.35±0.00^{d}	2.60±0.01^{g}	0.14±0.00^{f}
3	1.63±0.02^{a}	4.17±0.02^{a}	0.41±0.01^{c}
4	1.52±0.02^{b}	3.83±0.03^{b}	0.56±0.01^{b}
5	0.61±0.00^{c}	1.79±0.01^{e}	0.18±0.00^{e}
6	0.41±0.11^{d}	0.82±0.01^{f}	0.32±0.30^{d}
7	1.56±0.52^{b}	4.39±0.09^{d}	0.41±0.00^{c}
8	0.42±0.02^{d}	2.57±0.03^{c}	0.74±0.01^{a}

$^{a\text{-}f}$Any two means in the same column not followed by the same latter are significantly different ($p \leq 0.05$).

4.8.5. Calcium

Tables: 10 shows the result of calcium concentration in the salt samples were significantly different at $p<0.05$.

Table:9 shows that two of the table salts and two the common salts samples which were 3, 4, 5 &7 contain significant amounts of calcium. According to WHO standard the level of calcium should not exceed 5g/kg at maximum level but, the ES standard set 0.5g/kg for Table salt. The result agrees with the finding in Nigeria (Usman and Filli, 2013).The analysis of Calcium in raw salts in pakistan found to be 1.12 mg/kg (Attique and muhammed,2010).Recrystalization nearly remove 55-65% of Calcium from edible salts (Attique and muhammed,2010). Calcium ions in Solar and vacuum evaporated salts contained 0.005 - 0.05% calcium ions in crystals. The content of calcium ions of solar salts were found to be about 0.01% in salt (Masuzawa, 1979).

4.8.6. Magnesium

The result in table: 10 shows that each value of the samples were significantly different at ($p<0.05$).

The ES specifies 0.5 g/kg of magnesium. Table: 9 Shows that only two of the table salt samples 1 and 2 results agreed with the specification. The Magnesium content of other salts samples did not confirm the recommended quantity. This might be due to the following reason; Geologists, explain the Afar mineral salt deposition as the product of the Quaternary era's geological processes of intensive sedimentation. This process ultimately left huge mineral deposits magnesium that blossom the area, though salt still dominates the plains (Solomon, et al., 2011). The Magnesium content of all the salt samples analyzed in Nigeria were found to be 3.0g/kg (Usman and Filli 2013). Recrystalization removes 80-90% of Magnesium (Attique and muhammed,2010). Magnesium increase moisture content of the salt (Kelly, 1953). Mg is associated with abnormal irritability of muscle and convulsions and excess Mg with depression of the central nervous system (Budavari, 1997).

4.8.7. Iron

Each values of the samples in table 10: were significantly different at ($p<0.05$).

Table: 9 shows all the samples of the salts of iron conform to the specification of all the different bodies. The Ethiopian Standard specifies 10 mg/kg. All the samples meet the standards and none of them exceeded the recommended quantity. (Usman and Filli, 2014) found that the salt samples in Nigeria contains 0.9 mg/kg. (Longdet, et al., 2013) reported that 0.308 mg/kg of iron in salt consumed in Nigeria. In Pakistan the chemical analysis of purified salt samples after chemical treatment were found to be in range 0.0011-0.0749 mg/kg (Attique and muhammed, 2010).The presence of metal impurities including iron in salts has been attributed to inefficiency of purification processes (Usman and Filli, 2014).

5. CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

This study clearly revealed that, many of common salt producers and table salt re-processors are now failing to add iodine in quantities sufficient to support optimal health.

The study also demonstrated, only one of the sample of table salt (2) meet the standard set by both national and international bodies in terms of sodium chloride, Loss of Mass, Matter Insolubility, sulphate, and Alkalinity, except iodine content and pH.

The study indicates that the heavy metals in all the salt samples were below or within the range of the recommended limit of (FAO/ WHO, 2003). Cd, Pb, Zn, and Cu in the edible salts are lower than safety threshold values provided by ES.

This study as well reported that all the samples contain less amount of iron. But, there were a significant amount of magnesium within each sample and exceed the level set by ES. Two of the table and common salts contain high levels of calcium.

5.2. RECOMMENDATIONS

The following recommendations should be taken into consideration:

- ✓ Further research work should be done to optimize the current solar salt production at Production site.
- ✓ It is also important that a detailed chemical analysis should be done to identify the constituent elements with a higher precision.
- ✓ Proper storage and focusing on checking quality of chemicals.
- ✓ Producers must explore possibility for solving the existing bottlenecks (assigned production quota) by producing limited amount.
- ✓ When planning for salt iodization it’s important to assess the quality of edible salts in terms of chemical composition and physical contaminants

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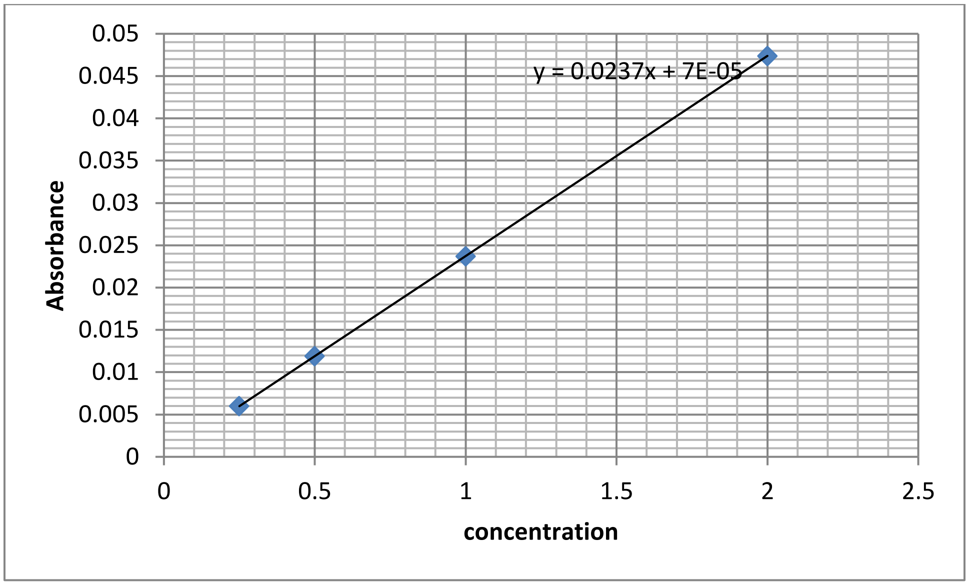
APPENDICIES



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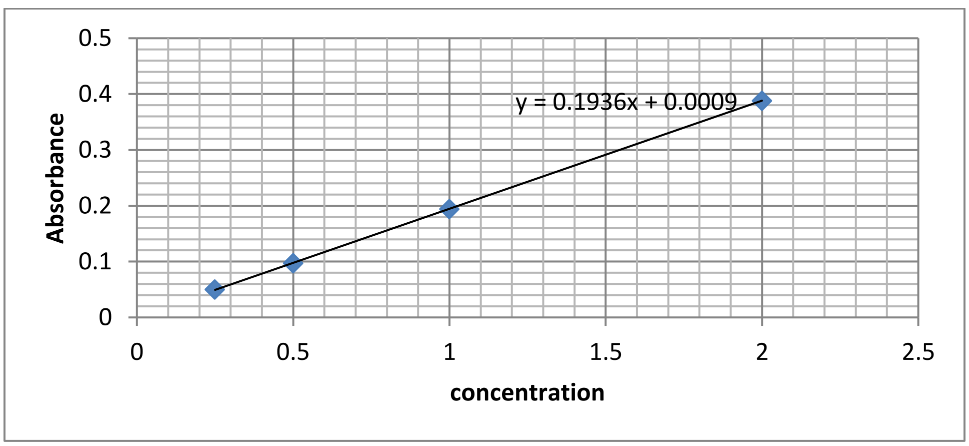

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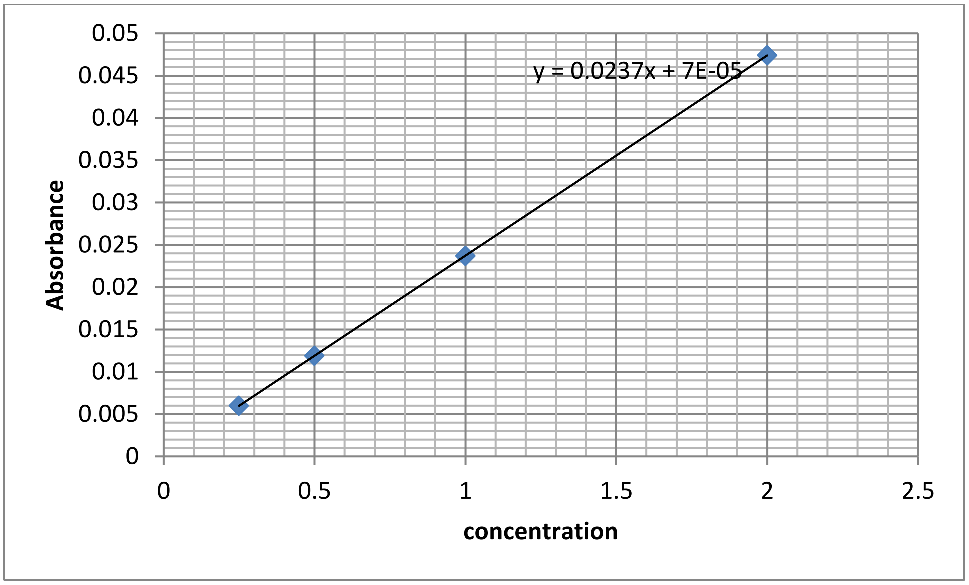

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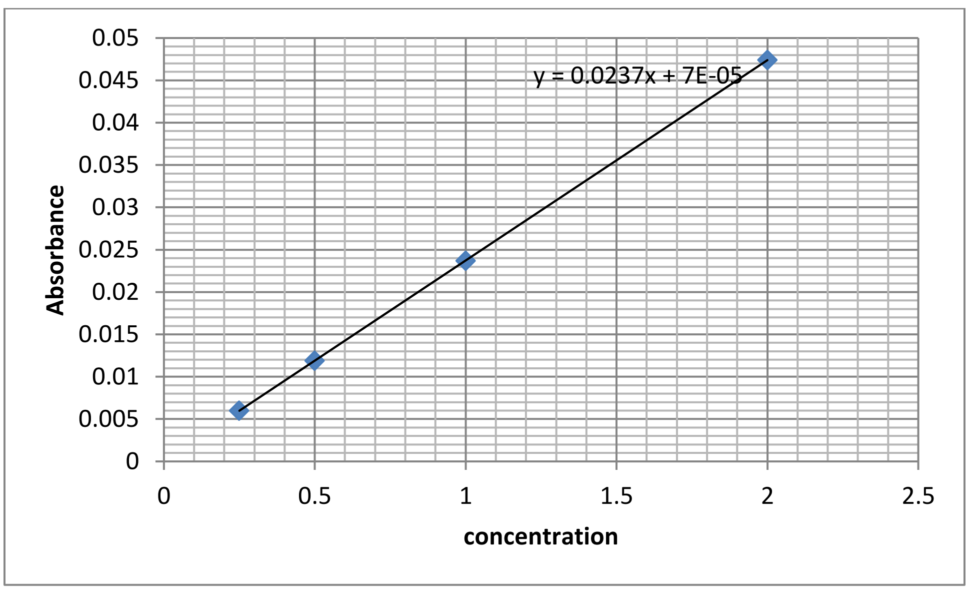

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