

**SALT IODIZATION
FOR THE
ELIMINATION OF IODINE
DEFICIENCY**

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by

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PREFACE

About 1.5 billion people, or nearly one-third of the Earth's population, live in areas of iodine deficiency. Its consequences, the so-called iodine deficiency disorders (IDD), include irreversible mental retardation, goiter, reproductive failure, increased child mortality, and socioeconomic compromise. All of these results can be prevented by sufficient iodine in the diet. Eliminating iodine deficiency is recognized as one of the most achievable of the goals that the 1990 World Summit for Children set for the year 2000.

Iodized salt is the best means for providing iodine to iodine-deficient populations. It is physiological, simple, practical, and effective. This book provides a short non-technical introduction to its production and use. The initial sections give a background on the iodine deficiency disorders. We then describe salt production and iodization, quality control, monitoring, and marketing. Additional chapters consider the central role of iodized salt in national plans for IDD elimination. Our intended audience is salt producers and distributors, government officials in industry, trade and health sectors responsible for iodine deficiency control programs, relevant national and international agencies, and all other individuals concerned with iodine deficiency and its prevention.

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1. THE IODINE DEFICIENCY DISORDERS

Healthy humans require iodine, an essential component of the thyroid hormones, thyroxine and triiodothyronine. Failure to have adequate iodine leads to insufficient production of these hormones, which affect many different parts of the body, particularly muscle, heart, liver, kidney, and the developing brain. Inadequate hormone production adversely affects these tissues, resulting in the disease states known collectively as the iodine deficiency disorders, or IDD. These consequences include: (1) mental retardation, (2) other defects in development of the nervous system, (3) goitre (enlarged thyroid); (4) physical sluggishness; (5) growth retardation, (6) reproductive failure, (7) increased childhood mortality; and (8) economic stagnation. The most devastating of these consequences are on the developing human brain.

Iodine deficiency has been called the world's major cause of preventable mental retardation. Its severity can vary from mild intellectual blunting to frank cretinism, a condition that includes gross mental retardation, deaf mutism, short stature, and various other defects. In areas of severe iodine deficiency, the *majority* of individuals risk some degree of mental impairment. The damage to the developing brain results in individuals poorly equipped to fight disease, learn, work effectively, or reproduce satisfactorily.

In addition to mental retardation, goitre is an important consequence of iodine deficiency. In this instance, thyroid enlargement can be viewed as an attempt to compensate for inadequate hormone production by the thyroid, in turn a consequence of insufficient iodine for hormone synthesis. The pituitary gland at the base of the brain secretes its own hormone - TSH (thyroid stimulating hormone) - in response to the levels of thyroid hormone circulating in the blood; when thyroid hormone production is low, the pituitary secretes more TSH. This increased stimulation causes thyroid enlargement. The resulting goitre is a marker for iodine deficiency, and is particularly useful because it is easily assessed. While the effects on the developing brain are the most important consequence of iodine deficiency, the goitre is also important because it can lead to significant morbidity from compression and altered thyroid function.

Unlike nutrients such as iron, calcium or the vitamins, iodine does not occur naturally in specific foods; rather, it is present in the soil and is ingested through foods grown on that soil. Iodine deficiency results from an uneven distribution of iodine on the earth's crust. Ocean water contains adequate amounts of iodine, and thus persons living near the sea and those eating sea fish and products like kelp are more likely to be iodine sufficient but these are not accessible to everyone. Soils from mountain ranges, such as the Himalayas, Alps, and Andes, and from areas with frequent flooding, are particularly likely to be iodine deficient. The problem is aggravated by accelerated deforestation and soil erosion. This deficiency in the soil cannot be corrected. The food grown in iodine deficient regions can never provide enough iodine to the population and livestock living there. Many other areas of the world also harbour severe iodine deficiency, such as large parts of central Africa. Living on the sea coast does not guarantee iodine sufficiency, and significant pockets of iodine deficiency have been reported from the Azores, Bombay, Bangkok and Manila for example. A recent WHO/UNICEF/ICCIDD Report estimates that currently at least 1.570 billion people (or 29% of the world's population) live in areas of iodine deficiency and need some form of iodine supplementation. Most of these are in developing countries in Africa, Asia, and Latin America, but large parts of Europe are also vulnerable.

2. THE THRUST AND RATIONALE FOR IDD ELIMINATION

Iodine deficiency thus results mainly from geological rather than social and economic conditions. It cannot be eliminated by changing diet habits or by eating specific kinds of foods grown in the same area. Rather the correction has to be achieved by supplying iodine from an external source. This can be done in two ways: by periodic supplementation of deficient populations with iodized oil capsules or other preparations, or by fortifying a commonly eaten food with iodine. While both strategies are effective, the iodization of salt is the common, long term and sustainable solution that will ensure that iodine reaches the entire population and is ingested on a regular basis. Fortification of salt has been extremely successful in eliminating iodine deficiencies in North America and many parts of Europe. In specific areas that iodized salt will not reach soon, iodized oil supplementation is sometimes recommended as a short-term intervention.

Why iodize salt?

In the rural areas of many developing countries, where iodine deficiency is most severe, the populations are largely dependent on subsistence foods. Their diet is typically based on one or two cereals, tubers or pulses as the staple. If the household has any livestock, it may also consume some dairy products. It is this dietary and economic context that must be considered while choosing a vehicle for iodine to reach such populations.

Over the past 60 years, in the effort to introduce iodine regularly into the daily diet, several foods have been considered as possible vehicles. These include salt, bread, sweets, milk, sugar and water. Among these salt has become the most commonly accepted owing to a variety of reasons:

- It is one of the few commodities that come close to being universally consumed by almost all sections of a community irrespective of economic level. It is consumed at approximately the same level throughout the year in a given region by all normal adults. Thus, a micronutrient like iodine when introduced through salt will be administered to each individual at a uniform dosage throughout the year.
- Compared to other food commodities whose production is widely dispersed the production of salt is generally limited to a few centres. In many remote areas of the world, salt is one of the few commodities that comes from outside the area, thereby lending itself to processing on an economical scale and under controlled conditions. By adding a fixed dosage of a micronutrient like iodine to salt at centralised locations, a majority of the population all over a region or country will ingest the nutrient in physiological amounts continuously with no additional effort.
- The mixing of an iodine compound with salt is a simple operation and produces no adverse chemical reactions. The equipment required is uncomplicated, easy to operate and maintain.
- A major portion of salt produced in the world is from sea water. Sea water contains iodine in addition to salt. However, when sea water evaporates, much of the iodine either remains in solution or is lost by evaporation. Only a small portion of the iodine is retained in the salt. Iodization, therefore, restores a natural constituent of sea salt.
- The addition of iodine to salt (usually as potassium or sodium iodide or iodate) does not impart any colour, taste or odour to the salt. In fact iodized salt is indistinguishable from uniodized salt.

- The cost of iodization is low: normally in the range 2-7 US cents per kilogram, which is less than 5 % of the retail price of salt in most countries.

Since iodine is required in very minute quantities of the order of 150 -200 micrograms per person per day, the dosage of iodine in salt is extremely small. Salt consumption could be anywhere in the range 5 - 20 grams a day within a given region or country. Normally the iodine concentration in salt is fixed in the range 30 - 100 micrograms of iodine in one gram of salt. This dosage is determined after taking into account anticipated iodine losses during transport and storage. Iodized salt needs to be packaged in waterproof bags or containers and labelled with an indication of the name and address of the producer and date of manufacture to enable monitoring.

In certain parts of the world, there are populations that do not consume salt from a regular production source. They collect rock salt or saline twigs that are locally available and boiled to extract the salt. Sometimes they boil saline brines to produce small quantities of salt sufficient for the household. It is difficult to reach such populations through the medium of salt, but improved marketing and availability of commodities for these populations should encourage them to purchase salt.

Once the effective iodization of salt is established as a permanent measure in a country, it eliminates iodine deficiency and continues to provide each individual his daily iodine needs and prevents recurrence. Within one year of iodized salt containing the required concentration of iodine becoming widely available and consumed in a community, there will be no further birth of cretins or children with subnormal mental and physical development attributable to iodine deficiency. Goitres, in primary school children and young adults, will have started to shrink and even disappear altogether. Children will be more active and perform better at school. Further enlargement of the thyroid in adults will be prevented. The introduction of iodine through salt has been successful in eliminating the problem of iodine deficiency and been ongoing in several countries for over 60 years. The challenge today is to apply available knowledge to establish systems to deliver iodine to the entire population on a continuous and self-sustaining basis.

3. GLOBAL ACTION FOR IDD ERADICATION

Health planners and international agencies are increasingly recognizing that the elimination of iodine deficiency is an attainable goal with important benefits for many people. The planning of a global strategy for the prevention and control of IDD has been taken up by the United Nations Administrative Committee on Coordination - Subcommittee on Nutrition (ACC/SCN). In October 1985 the ACC/SCN requested the World Health Organization (WHO) to prepare an international support programme for IDD control. The 39th World Health Assembly (Geneva, 1986) in its resolution urged all member nations to give high priority to the prevention and control of IDD within the ensuing five to ten years and requested the Director General of WHO to give all possible support to the member states in this regard. The International Council for the Control of Iodine Deficiency Disorders (ICCIDD) was formed in 1986 to function as an expert consultative group on the assessment and control of IDD, operating with WHO and UNICEF at the global, regional and national levels. ICCIDD has also formed regional working groups in Africa, South East Asia and the Middle East for developing regional strategies for IDD control.

The World Summit for Children held in New York in September 1990, called for the virtual elimination of iodine deficiency disorders by the year 2000. The International Conference on Nutrition, December 1992 called on governments in collaboration with international agencies, NGOs, the private sector/industry, other expert groups and the community to "...ensure and legislate for the fortification of foods or water with the necessary micronutrients...where iodine deficiency is a significant public health problem, the iodization of salt for both human and livestock consumption is required, recognizing that this is the most effective long range measure for correcting iodine deficiency."

The main strategy to achieve the goal will be the universal fortification of all 'food-grade' salt consumed by all people in countries at risk by the end of 1995. All salt for animal use should also be fortified, since such salt is often consumed by people, and improving the iodine status of animals will improve animal reproduction, milk and meat yield and increase the iodine content of food.

Country strategies

As of 1994 it was estimated that there were more than 90 developing countries with iodine deficiency as a public health problem. These countries can be classified into three groups depending on their main source of salt and the ease with which salt can be fortified:

- A. Countries where there is virtually no domestic salt production and almost all salt used is imported. In these countries the ideal strategy will be for salt to be properly iodized in the country of origin. Compared to cost of packaging and transportation, the additional cost of iodization should be low. These costs might be absorbed by consumers or through more efficient and competitive purchasing. Thirty five countries, many of them small and landlocked are in this category.
- B. Twenty six countries where most salt is processed and packed in a small number of large modern refineries or where extensive salt iodization is already under way. In these countries, iodization is likely to be simple, straight forward and acceptable and will involve only marginal cost increases. The main needs will be for advocacy and monitoring and loans for purchase of equipment. Some of these countries are exporters, and ensuring that all salt is iodized will help reduce IDD in importing countries.

- C. Thirty countries where most salt is produced by large numbers (several hundreds or even thousands) of traditional salt producers who produce variable quality salt on a cottage scale. Universal salt iodization will be the most expensive and difficult to achieve in these countries. Small producers will need to be supported and encouraged to distribute their salt through group operated refineries that can be well managed and monitored.

4. CONSUMPTION AND USES OF SALT

Salt has played a prominent part in the development of man's activities, trade, politics and culture from prehistoric times. Part of its overwhelming influence stems from its role as a source of sodium and chloride, two dominant chemical constituents of the human body with important metabolic functions. Also this inexpensive and abundantly available commodity is an important raw material in today's industry for the manufacture of chemicals that are used in the manufacture of plastics, aluminium, paper, soaps and glass. Directly or in the form of derivatives, salt finds application in more than 14,000 ways.

History and culture of salt

Man's primary use of salt is as an essential dietary item for both him and his domestic animals. Salt has also been used from pre-historic times for flavouring, pickling, preserving, and curing meat and fish, and for tanning. These features have made salt an important part of human culture and civilization. As one writer points out 'From cells in our brains and bones to customs that spice our languages, salt penetrates every aspect of our existence'. Expressions such as 'worth his salt,' 'above the salt,' 'old salt,' 'loyal to one's salt,' 'the salt of life,' and 'salary,' are used every day. Different cultures have variously held salt as a symbol of divinity, purity, welcome, hospitality, wit or wisdom. In Sanskrit the word "lavanya" expressing grace, beauty and charm, is derived from the word for salt "lavana."

Salt has been equally important in trade and politics. Many earlier cultures used it as currency. Some primitive tribes gave gold, weight for weight, to purchase salt. The Hanseatic league developed initially on the salt trade. Many countries controlled salt as a state monopoly. The salt tax, among other things, provoked the French Revolution. A similar salt tax was a principal issue in Gandhi's civil disobedience movement against the British that eventually led to India's independence.

Salt for human consumption

In the human body, sodium is essential to muscle movement, including that of the heart, to the peristaltic movement of the digestive tract, and to the transmission of messages by the nerve cells. The chloride ion produces hydrochloric acid required for digestion and is present in salivary amylase. A principal function of salt is to regulate osmotic pressure and the movement of fluid to and from the cell. For normal health, the salt concentration in the body can vary only within narrow limits. Lost salt must be replaced. Most leaves the body as sweat. Salt is also excreted through urine, carefully regulated by the kidneys to maintain bodily levels at the appropriate level. Most salt in the gastric juices and digested food is reabsorbed in the intestines, but increased bowel motility and diarrhea can deplete body salt.

Chronic salt deprivation produces loss of weight and appetite, inertia, nausea and muscular cramps. Excessive heat as in desert summers depletes body salt, leading to possible vascular collapse and death. On the other hand, excessive sodium in salt and other foods can contribute to hypertension, and to heart, liver and kidney diseases.

While salt is perhaps the only food item other than water that is universally consumed, its intake varies considerably with factors such as climate, culinary habits and occupation. Hot tropical summers and heavy manual work with excessive sweating increase salt requirements. The rice-eating populations of the world also consume more salt (15-20 g/day) than others because rice is very deficient in salt. In temperate climates consumption is much lower (5-8 g/day).

Salt for animal consumption

Animals need salt as much as humans do. Insufficient salt stunts the growth of young animals and produces lassitude, lowered production of milk and loss of weight in adults. Since fodder and plant life have little salt, domestic animals must receive salt with their feed. In modern farms, salt also provides a vehicle for vitamin and mineral supplements that are essential to the good health of livestock.

Salt for industrial consumption

The uses and importance of salt have multiplied with the advent of industrial civilization. Today only 6% of the world's annual salt production goes directly for human consumption. Most of the rest is used industrially as one of the "Big Five" basic ingredients of the chemical industry, together with sulphur, coal, limestone and petroleum. The largest industrial consumer is the chlor-alkali industry, which produces chlorine, caustic soda and soda ash for manufacture of plastics, paper, soaps, detergents, insecticides, and glass. The food industry needs salt for canning, baking, processing of flour and other foods, meat packing, fish curing, dairying and food flavouring. Other direct industrial uses are leather tanning, highway de-icing, oil well drilling and manufacture of dyestuffs and textiles.

These are only some of the main applications of salt. As the frontiers of the chemical industry grow, new applications for salt and its derivatives are constantly being discovered and are leading to an ever growing role for salt in the future.

Salt as a vehicle for micronutrients

Since humans universally consume salt in small fairly constant amounts daily, it is an ideal vehicle to deliver physiological amounts of micronutrients like iodine to the population at large. The concept of salt fortification is not new. Iodization of salt has been practised successfully in several countries for over 60 years. In some developed countries, salt for cattle is also used as a carrier for trace minerals such as manganese, zinc, copper, iron, cobalt and magnesium. Bread manufacturers add salt premixes containing iron, niacin, riboflavin and thiamine hydrochloride to their dough. In some countries, e.g., Switzerland and Colombia, salt is used as a carrier for sodium and calcium fluorides, and in India, table salt fortified with iron is being marketed on a trial basis.

5. SALT PRODUCTION METHODS AND PRACTICES

The production of common salt is one of the most ancient and widely distributed industries in the world. Salt is produced by mining of solid rock deposits and by the evaporation of sea water, lake, playa (desert basin) and underground brines. Rock and solar salt account for roughly 50% of production each. The requirements of Europe and North America are met mostly by mining while in Asia, Africa, Australia and South America, solar evaporation is the main source. The physical and chemical composition of salt produced from the various sources varies widely depending upon the manufacturing techniques, climatic conditions and processes adopted.

Mined Salt

Solid rock deposits of salt occur widely in North America, Europe and Central Asia, at depths ranging from a few hundred meters to more than a thousand meters. Where the deposits are fairly shallow, the dry mining method is preferred. This consists of sinking a shaft into the ground down to the salt layer and then blasting and removing the salt by the room and pillar method leaving a layer of salt above and below connected by pillars at regular intervals.

Where the deposit is very deep, solution mining is used. By this method, fresh water is injected at high pressure through a pipe into the salt layer where it dissolves the salt and forms a cavity. The saturated brine then travels through a concentric pipe upwards to the surface where it is treated and evaporated in vacuum pans to yield a high purity product. Occasionally the brine that is brought to the surface is evaporated by solar heat in open ponds. Salt deposits are often very pure and the mined salt then requires very little purification. Rock salt rarely contains magnesium impurities. Gypsum and other insolubles are frequently present but can be separated. The moisture of rock salt is usually much lower than that of solar salt.

Solar Salt

Salt has been manufactured by the solar evaporation from sea water and from inland underground or lake brines since time immemorial. In most developing countries, this method still predominates. The extraction of salt from sea water consists of progressive evaporation of brine in large open ponds using solar heat and wind. As the brine evaporates its concentration rises and the constituent salts crystallise in a set order. During this process, the sodium chloride fraction is separated from the brine over a fixed concentration range in a series of flat rectangular ponds and deposits as a uniform crust. This salt is 'harvested' by a variety of processes ranging from simple hand labour to the use of mechanized equipment to scrape the salt and transfer it through a series of conveyors for storage and draining.

The principal salts that crystallize from sea water along with sodium chloride are the chlorides and sulphates of magnesium, calcium and potassium. The harvested salt in the form of wet crystals can be washed with saturated brine to remove insoluble matter like sand and clay as well as the soluble impurities. It is then allowed to drain and dry in the sun and crushed to a coarse or fine powder as required. Any required additives are added at this point before the salt is packed for sale.

Crude salt produced in a properly designed salt works has a purity of 90-95% NaCl, 1% calcium salts and 1-2% magnesium salts and 5-8% water. If the salt is washed and dried its purity can be improved up to 99%.

Since iodine is a constituent of sea water, it is often incorrectly assumed that sea salt contains sufficient iodine for nutritional purposes. The total dissolved salts in seawater contain less than 2 micrograms of iodine per gram of salts, equivalent theoretically to about 3 micrograms of iodine for every gram of recovered sodium chloride (3 parts per million). Even this small quantity of iodine is mostly lost in the residual mother liquor that is drained out during the production process and should be disregarded in calculations to establish the level of iodine supplement.

In most underdeveloped countries, solar salt manufacture continues to be produced along coastlines or lakeshores as a semi-agricultural operation. The smaller units often operate with a minimum of organization and little or no quality control. The small fields are scattered along the coast or lake shores and do not lend themselves to regulation by the government. Very often, precise figures regarding even their location, extent of holdings and production statistics are not available. The producers have limited financial means and lack access to technical or financial assistance. As a result the salt produced in these units is of poor quality with purity as low as 85-90% and is visibly contaminated.

World salt production

Continent-wise distribution of world salt production is given in Table 5.1. Some countries depend entirely on rock salt, some on solar salt. In a few countries both forms are produced. Salt manufacturing techniques and product quality vary considerably from extremely primitive cottage scale units producing a few hundred tons a year to very large fully automated plants producing several million tons.

Continent	Production (Million tons)
Europe	73.6
North America	56.2
Asia	36.5
Central and South America	6.0
Oceania	5.9
Africa	3.3
TOTAL	181.5

Table 5.1 - Approximate current world salt production

The demand for salt increases with growth of population as well as with the development of industries. Apart from human consumption, chemical industry is a large bulk consumer of salt for

chlor alkali manufacture. In the developed countries, industrial requirements are several times the edible consumption. In the USA for instance nearly 97% of the total production of approximately 40 million tons is used for non-edible purposes. In the developing countries, the trend towards increased industrial demand is becoming apparent only during the past few years.

A brief review of the status of the salt industry in the world is presented below.

Europe

Poland, Germany, Czechoslovakia, Hungary and Holland mine rock salt almost exclusively. France and Italy have facilities for both rock and solar salt production. Russia and the Newly Independent Republics, Bulgaria and Rumania have a relatively small proportion of solar salt production from the waters of the Black Sea and the Sea of Azov; the bulk of their requirement is met by rock salt mining. Greece, Spain and Yugoslavia depend almost entirely on solar salt although they have rock salt deposits also. In the hinterland of Spain there are salt springs and saline lagoons from which salt is produced. Portugal produces rock salt and solar salt in almost equal quantities.

North America

A major portion of salt produced in USA and Canada is by the dry and solution mining of underground deposits. There is a small amount of solar salt production along the California coast and in Utah and Arizona.

Asia

The Middle Eastern countries like Syria, Iraq and Iran depend mostly on rock and playa salt. Turkey is an exception and concentrates on solar salt production. In recent years large solar salt operations have been developed in Turkey, Iraq and Iran. Israel and Jordan produce small quantities of solar salt from the Dead Sea.

In the Indian sub-continent, Pakistan and Afghanistan have extensive rock salt deposits and brine springs. India, Sri Lanka, Bangladesh, Thailand and Indonesia produce almost all their requirements by solar evaporation of sea water, underground springs or inland lakes. In these countries the size of operations varies from very small to large. In Indonesia, a Government-owned company accounts for 30% of the country's production. The production methods adopted in Kampuchea and Vietnam are basic and individual holdings are extremely small. However these countries are self-sufficient in salt. In China salt making has had an important role from ancient times. In spite of significant rock salt resources, about 75% of the country's production is sea salt. The rest comes from underground brines in the south and lake brines in the north and northwest. In the Philippines, North and South Korea and Taiwan, salt is produced entirely by the solar evaporation of sea water in small and medium sized operations. In Japan, the pressure on the availability of land has encouraged the development of sophisticated ion exchange techniques to recover salt directly from sea water. While the country is self sufficient in edible salt, it imports large quantities of industrial salt from Mexico and Australia.

Central and South America

The production of salt by solar evaporation of sea water predominates in Mexico where the world's largest solar operation is located in the Baja California desert. Small and medium sized

saltworks managed by individuals or cooperatives also operate. Small quantities of solar salt are produced in the Central America countries of Costa Rica, Guatemala, Nicaragua, Honduras and Panama. In South America, Brazil is the largest salt producer, mostly by solar evaporation. Venezuela also operates large solar salt works. In Uruguay solar salt production has been attempted but abandoned. Chile and Paraguay have no significant salt production. In Argentina and Peru all solar salt is produced from brine wells. In Cuba, salt is produced almost entirely by the solar evaporation of sea water. Bahamas and the Netherlands Antilles have recently emerged as large scale producers of sea salt.

Oceania

Australia has enormous reserves of rock salt as well as facilities for solar salt manufacture along the West and Southern coasts. In Western Australia, five companies produce 6-8 million tons in large mechanized solar salt operations, mainly for the Japanese market. New Zealand produces small quantities of solar salt to meet domestic requirements.

Africa

The North African countries have by far the most favourable conditions in the continent for solar salt manufacture. These include Algeria, Morocco, Tunisia and Egypt. In these countries there are large as well as medium and small producers. Salt production techniques in most Sub-Saharan African countries (barring South Africa and Namibia) are conventional and in some areas primitive. In Eritrea, there are two major Government-owned sea salt operations on the Red Sea coast and several privately-owned small and medium sized operations. These units meet the requirements of both Eritrea and Ethiopia. Kenya and Tanzania produce sea salt and some inland lake and subsoil brine salt. Mozambique and Angola have potential for production that is slowly regaining momentum. There is almost no salt production in the entire Central and West African region except for Ghana and Senegal. These two countries meet the requirements of most of the region. Countries like Nigeria prefer to import their requirement of table salt from outside the region. Small quantities are also produced in Sierra Leone, Togo and Guinea. South Africa and Namibia are the main sources of salt in Sub-Saharan Africa. There are major sea salt operations at Walvis Bay and Port Elizabeth. A new company manufacturing soda ash and salt from an inland lake near Sua Pan in Botswana may also emerge as a major exporter.

Most of the world output of salt (more than 80%) is consumed in the country in which it is produced. Since bulk salt for industrial use has a relatively low value, transportation costs usually form a large part of the delivered cost. This is an important factor in international trade. Japan is the world's largest importer of industrial grade salt. Significant quantities of salt move across borders between the USA, Canada, Mexico and the Bahamas. There is a fairly widespread international trade in refined salt for table use.

6. SALT QUALITY AND REFINING TECHNOLOGY

The physical characteristics and chemical composition of salt vary widely, depending upon the composition of the raw material and the manufacturing process. These features are detailed in Table 6.1 for commonly used varieties of salt. Table 6.2 sets out the specifications for salt as prescribed by the Codex Alimentarius. Briefly, salt for iodization should be at least 98% NaCl by weight, and less than 0.2% calcium, 0.1% magnesium, 0.5% sulphate, 0.5% insolubles, and 3% moisture. In the less developed countries where IDD is more prevalent, the salt commonly consumed is usually the coarse crystalline variety.

Type of salt	NaCl	Mg	Ca	SO ₄	Insolubles
Pure Vacuum Evaporated salt	99.95	0.0001	0.002	0.04	tr
Vacuum salt	99.70	0.01	0.01	0.2	tr
Refined salt	99	0.05	0.06	0.2	0.02-0.3
Solar salt	96-99	0.01-0.17	0.04-0.3	0.11-2.0	0.05-0.6
Rock salt	90-99	0.01-0.17	0.04-1.1	0.2-1.3	0-5

Table 6.1 - Typical chemical analyses of different types of salt (Dry Basis)

In many developing countries, salt after extraction from the sea, lake or underground deposits will typically consist of crude lumps or granules which contain, in addition to sodium chloride, sand, mud, other salts and organic matter. This crude salt is generally off-white or yellowish-brown in colour. This crude salt is often used directly for some industrial purposes, for livestock use and in some countries even for human use.

Processes for refining salt

Refined salt is very pure (NaCl content 99.5%), dry, and white with uniform grain size (0.3 - 1.0 mm). Depending on application, it is sold with or without additives such as:

- anti-caking agents, to prevent adjacent grains cementing together to form a hard solid mass; commonly used agents are potassium or sodium ferrocyanide in the range 5-15 parts per million;
- free flowing agents, to provide the crystals with a mechanical coating that acts as a lubricant and absorbs any water vapour within the package after sealing; commonly used free flowing agents are magnesium carbonate, calcium silicate, sodium silico-aluminate and tricalcium phosphate, at a level of 1-2%; and
- iodizing agents to control iodine deficiency disorders, such as potassium iodide or iodate at a level of 30-170 ppm

CODEX STAN 150-1985

(a) food grade salt is the crystalline product consisting predominantly of sodium chloride. It is obtained from the sea, from underground rock salt deposits or from natural brine. This standard applies to salt used as an ingredient of food, both for direct sale to the consumer and for food manufacture. It applies also to salt used as a carrier of food additives and/or nutrients.

(b) shall have a content of NaCl not less than 97% on a dry matter basis exclusive of additives.

(c) may contain the following food additives indicated in the relevant pages of Division 3 as listed below:

<u>Anticaking Agents:</u>	<u>Max. Level in the Final Product</u>
■ Calcium and/or Mg Carbonates)
• Mg Oxide; Tri Cal Phosphate;)
Silicon Dioxide; Ca, Mg, Na-alumino;) 20g/kg singly
or Ca-alumino silicates) or in combination
• Al, Ca, Mg, K or Na salts of)
myristic,)
palmitic or stearic acids)
• Crystal modifiers	10 mg/kg singly or in combination of Na,K or Ca ferrocyanides, expressed as [Fe(CN)6] *For Na and K ferrocyanides, max. level may be 20 mg/kg when used in the preparation of "dendritic" salt.
• Polysorbate 80	10 mg/kg
• Dimethylpolysiloxane	10 mg of residue/kg

<u>(d) Contaminants:</u>	<u>Maximum permitted level</u>
• Arsenic	0.5 mg/kg
• Copper	2 mg/kg
• Lead	2 mg/kg
• Cadmium	0.5 mg/kg
• Mercury	0.1 mg/kg

(e) in addition to the mandatory requirements found in the General Standard for Labelling of Prepackaged Foods, the following specifications apply:

- the name of the food shall be "salt".
- the name "salt" shall be qualified by a declaration of either "Food Grade" or "Cooking" or "Table" in close proximity to the name.
- when salt contains one or more ferrocyanide salt added to the brine during the crystallization step, may the term "dendritic" be included in conjunction with the name.
- an indication of either the origin or the method of production may be declared on the label.
- where salt is used as a carrier for one or more nutrients, and sold as such for public health reasons, the name of the product shall be qualified to indicate such purpose, e.g. "salt fluoridated", "salt fortified with iron".

when salt is used as a carrier for nutrients and sold as such for public health reasons, date marking is needed whenever the shelf life of the product is valid to the end of a given time.

Table 6.2 - Codex specifications for food grade salt

In many countries the crude salt is often directly ground and packed and marketed or refined before being sold for human and animal use. Many alternative processes exist for refining crude solar

salt. In some countries salt refineries may re-dissolve the crude salt and evaporate the brine under vacuum to obtain a fine pure recrystallized powder which is dried and packed. A more common procedure, increasingly adopted on account of lower energy consumption, is the hydromilling process. Each has advantages and drawbacks with respect to technology and economics. Both these processes are described below:

Recrystallization - (Fig 6.1) This is the standard method for producing salt for table, dairy and industrial purposes, the table salt being a screened size extracted from general production and treated with free flowing agents. Crude salt is dissolved in fresh water to make saturated brine, which is then treated with chemicals to precipitate calcium and magnesium impurities. The clear, treated saturated brine containing 305-310 g/L NaCl is fed into a triple effect vacuum evaporator system consisting of an evaporator, a tube bundle heat exchanger and a circulation pump. First, the brine is heated, to force evaporation in the upper part of the crystallizers, exceeding the saturation point in the brine and resulting in crystal formation. To control the heat during crystal formation more precisely, the brine contained in each crystallization stage is circulated by a pump. Brine is heated in the exterior heat exchanger. The first crystallization is heated by live steam, while the second and third crystallizations are heated by vapours from the previous stage. The live steam condensate from the heater of the first stage returns to the boiler house.

The salt slurry produced in the crystallizers is pumped from the evaporator legs to a settler tank. There the excess mother liquor is returned to the system. The thickened suspension is filtered and dried in a top feed filter to a moisture content of 0.15% or less. The dry salt is iodized and sprayed with anti-caking agent/free flowing agent. The product salt is passed through an oversize screen to remove any agglomerates, and then conveyed to silos for packing in bulk 50 kg High Density Poly Ethylene (HDPE) or Poly Propylene (PP) bags or retail 1 kg Low Density Poly Ethylene (LDPE) packs.

A variation of this process is the 'International Process,' (Fig 6.2) in which the crude salt is dissolved in a brine circuit by live steam in a direct contact heater and the hot slurry flash-cooled in an evaporator. On cooling, the solubility decreases and crystallization results. This method of crystallization eliminates the need for tubular heaters. The process can be adapted to multiple-effect evaporation and can also be designed to use thermo-recompression. It is more economical than the conventional vacuum crystallization process in both capital and operating cost.

Hydromilling - This is essentially a physical upgrading process in which the salt is ground and washed several times in saturated brine. The product is comparable in most respects to recrystallized salt and indistinguishable from it by the consumer.

In this process (Fig. 6.3) raw salt is fed into a hopper and delivered at a uniform rate through a roller feeder and bucket elevator to a hydromill, into which brine is also introduced. The hydromill grinds the salt and discharges it as a slurry into a receiving tank, to which fresh brine is then introduced. Gypsum and fine insolubles are separated by flotation with froth formed in the hydromill. The salt slurry is then passed through a slurry pump to a thickener, where it is further concentrated before being fed into a continuous centrifuge. The salt undergoes a fresh water wash and then is concentrated in a centrifuge until its moisture content is about 3%. Next, the centrifuged salt passes through a fluid bed drier, is dried to a moisture content of less than 0.15%, and then cooled. It then passes through a blender with screw conveyor for mixing with any additives. Finally, the salt is stored in silos and packed.

7. CHOICE AND DOSAGE OF IODINE COMPOUND FOR SALT IODIZATION

(The nomenclature for iodine is sanctioned more by general use than chemical logic. The term "iodine" usually refers to the chemical element in a general sense without specifying its chemical form, but it is also used to denote the form I_2 . Occasionally salt or another vehicle is described as "iodated" when potassium iodate (KIO_3) is added, or as "iodinated" when iodine (I_2) is added to a vehicle such as water. Recently WHO, ICCIDD, and UNICEF have recommended that the term "iodized" (also spelled "iodised") be used when iodine is added in any form).

Iodine is normally introduced as the iodide or iodate of potassium, calcium or sodium. Table 7.1 shows important physical properties of these compounds.

Name	Chemical Formula	% Iodine	Solubility in water (g/L)				
			0 C	20 C	30 C	40 C	60 C
Iodine	I_2	100			0.3	0.4	0.6
Calcium iodide	CaI_2	86.5	646	676	690	708	740
Calcium iodate	$Ca(IO_3)_2 \cdot 6H_2O$	65.0		1.0	4.2	6.1	13.6
Potassium iodide	KI	76.5	1280	1440	1520	1600	1760
Potassium iodate	KIO_3	59.5	47.3	81.3	117	128	185
Sodium iodide	$NaI \cdot 2H_2O$	85.0	1590	1790	1900	2050	2570
Sodium iodate	$NaIO_3$	64.0		25.0	90.0	150	210

Table 7.1 - Physical Properties of iodine and its compounds

Developed countries use both potassium iodide (KI) and potassium iodate (KIO₃) extensively for iodization of refined table salt. Table 7.2 lists a few countries with the potassium compound used and iodization levels:

Country	Iodine Compound used	Level of iodization at production level (mg Iodine/kg salt)
Australia	Potassium Iodate	65
Cameroon	Potassium Iodate	50
Canada	Potassium Iodide	77
China	Potassium Iodate	40
Ecuador	Potassium Iodide	40
Germany	Potassium Iodate	25
India	Potassium Iodate	30
Indonesia	Potassium Iodate	25
Kenya	Potassium Iodate	100
Nigeria	Potassium Iodate	50
Panama	Potassium Iodate/Iodide*	67-100
USA	Potassium Iodide	77
Zimbabwe	Potassium Iodate	50 (at point of entry)

* If KI is used it must be guaranteed that there is no significant iodine loss

Table 7.2 - Salt Iodization levels in selected countries

The high solubility of KI enables dispersion by atomized sprays on very dry crystals. However, KI in salt is not very stable and can easily be lost by oxidation to iodine if the iodized salt is subjected appreciably to any of the following conditions: (1) moisture in the salt, (2) humid or excessively aerated environment; (3) exposure to sunlight; (4) exposure to heat; (5) acid reaction in the salt; or (6) presence of impurities. It can also be lost if the iodized salt packages become damp, resulting in the migration of iodide from the salt to the fabric, and subsequent evaporation if the fabric is pervious. This loss can be lessened when the salt iodized with KI is very pure (+ 99.5%) and dry (moisture less than 0.1%), and by the addition of stabilizers such as sodium thiosulphate and calcium hydroxide, and/or drying agents such as magnesium carbonate or calcium carbonate. However, in most impure salt, KI stability is poor due both to oxidation and to migration and segregation in the presence of moisture.

Most people in iodine deficient areas use unrefined salt that can be effectively supplemented with KIO_3 without added carrier agents or stabilizers. Iodate is more stable under adverse climatic conditions than iodide and does not require stabilizers. It is also less soluble than iodide and less likely to migrate from the bag but is only sparingly soluble in water at low temperatures. However, solutions of up to 40 g/L (4% approximately) are readily obtainable. Such a solution is sufficient for salt iodization even at iodine levels of 100 mg/kg. The addition of 0.1% moisture to crude salt, which may already contain 1-5% moisture has no adverse effect. Potassium iodate breaks down rapidly in the human body and effectively delivers iodide to the thyroid gland for the synthesis of thyroid hormone. It is not toxic, and has been approved and recommended by the Joint FAO/WHO Expert Committee on Food Additives as safe when used within the Provisional Maximum Tolerable Daily Intake (PMTDI) for iodine of 1 mg from all sources. Even at the highest dosages currently used, iodine intake through iodized salt is unlikely to exceed 20% of this value.

As indicated in Table 7.1, iodine makes up a greater fraction of the weight of KI than it does of KIO_3 . KI is also cheaper than KIO_3 . However, when used in impure salt the overall cost of using KI may be higher owing to its relative instability. (Calcium iodate ($Ca(IO_3)_2$) is also stable in impure salts but has not been used extensively because of its very low solubility in water).

Table 7.3 illustrates the specific gravity of dilute solutions of potassium iodate. Potassium iodate is a heavy salt and solution strengths can be checked with precision hydrometers if desired.

% iodate	Specific gravity
1	1.00711
2	1.01572
3	1.02446
4	1.03334
5	1.04236
6	1.05153

Table 7.3 - Specific gravity of potassium iodate solutions (in water, at 18 °C, from "International Critical Tables")

Salt Iodine levels

The recommended minimum daily requirement of iodine varies from 150 to 200 µg. To visualize this quantity, a particle the size of a pinhead is sufficient for one person for one month. There is no universal specification for the level of iodine to be added to salt to achieve this recommended iodine intake. Numerous factors influence the selection of an appropriate level for a given population, including: (1) per-capita consumption of salt in the region; (2) the degree of iodine deficiency in the region; (3) transit losses; and (4) shelf life required. Per-capita consumption of salt in different countries varies over a wide range, from about 3 to 20 gms per day. Table 7.4 offers a sample calculation for fixing the level of iodization of salt:

- * Assume that the per capita daily requirement of iodine is 200 µg;
- * Assume that the per capita salt consumption is 10 g per day.
- * Level of iodine required in salt is 200 µg per 10 g (1 g = 1 million µg) or 20 parts per million (ppm);
- * Assume that half of the iodine may be lost in transit and storage;
- * Level of iodation required = 40 ppm iodine;
 = 40 x 1.685 ppm KIO₃;
 = 67 ppm KIO₃.

Table 7.4 - Sample calculation for fixing the level of iodization with KIO₃ in salt

Since levels of salt consumption vary and the amount of iodine lost from salt will depend on climate, packaging material and storage time (Fig. 7.1), it is not possible to establish a global standard for the quantity of potassium iodate which should be added to salt. Current levels of iodization in different countries vary from 100 parts of iodine per million parts of salt, which corresponds to 170 grams of potassium iodate per ton (where salt quality and packing is very poor coupled with low salt intake) to 20 ppm iodine, which is equal to 34 grams per ton (high quality salt, good packing, high salt intake). Most countries have fixed levels around 50 ppm iodine (which corresponds to 85 ppm potassium iodate).

In a given country the fortification level may be changed over time, in response to changes in average daily consumption of salt and reduction in iodine losses during distribution and storage. WHO/UNICEF/ICCIDD-recommended levels of iodine in salt for different salt consumption levels, environmental and packing conditions are summarized in Table 7.5. National authorities should establish suitable levels in consultation with the salt industry. National regulations should establish a minimum level of iodine at production level and a lower level at consumption level to allow for storage and transit losses e.g. minimum permitted level at production 40 ppm, minimum level at consumption 20 ppm.

Discussions and regulations about iodine levels in salt must clearly specify whether they refer to total content of iodine alone or to content of iodine compound (KIO₃ or KI). From the example above, 40 ppm as iodine is the same as 67 ppm as KIO₃ or 52 ppm as KI, offering a ready source for confusion unless the chemical form is clearly identified. In general **we recommend that the level be expressed as content of iodine alone**, which emphasizes the physiologically important component (iodine) and facilitates comparison of its different chemical forms.

Climate and Daily salt consumption (g/person)	Packaging			
	Required at factory (external)		Required at retail salt	
	Bulk Sacks	Retail Plastic bags	Bulk Sacks	Retail Sacks
	<i>mg Iodine/kg salt</i>			
Warm moist:				
5g	100	80	80	60
10g	50	40	40	30
Cool dry:				
5g	80	60	60	40
10g	40	30	30	20

Table 7.5 - WHO/UNICEF/ICCIDD recommended levels of iodine in salt, expressed as mg iodine per kg salt (ppm)

Iodine Procurement

Iodine production in the world is limited to a few countries. Japan and Chile are the principal producers and exporters. The current (1994) CIF (Cost insurance and freight) price of elemental iodine is around \$8-8.50/kg. For IDD control programs, iodine is usually imported in the form of potassium iodate.

Many manufacturers produce and supply potassium iodate, both in developed and developing countries. Some of them are listed below:

- Helm - Hamburg, Germany
- Johnson Matthey - Paris, France
- ACF Chemie - Maarsse, Netherlands
- William Blythe Ltd. - Lancashire, England
- MBI Chemicals - Madras, India

However, UNICEF's Supply Division has entered into a Long-Term Arrangement for the supply of potassium iodate with the world largest iodine manufacturer, INQUIM in Chile, for reasons of quality, price, performance, etc. The product is packed in new fibre drums with a sealed heavy duty polyethylene bag of 50kg net, and is available at the price of:

- US\$ 7.70/kg, FOB Valparaiso or Singapore or Antwerp.

The specifications of the Potassium Iodate purchased from INQUIM conform to the U.S. Food Chemical Codex (FCC). When ordered from other sources FCC or equivalent standard should be requested. "Edible grade" and "technical grade" should not be used as a description of the standard.

Normally for procurement of potassium iodate, U.S. Food Codex Specifications are followed. Quality specifications for potassium iodate are set out in Table 7.6. If the country's requirement is large (at least 30 Tons/year), it may be more economical to import elemental iodine and convert it to KIO₃.

Conversion of Iodine to Potassium Iodate

Potassium iodate is produced by the electrochemical reaction of elemental iodine with potassium hydroxide (KOH):



Iodine is dissolved in potassium hydroxide solution and the potassium iodide so obtained is electrolytically oxidised in an annular flow cell. At the end of the electrolysis, the electrolyte is cooled and potassium iodate is obtained. Approximately 80% of KIO₃ crystallizes from the reaction mixture. After filtration, the electrolyte is recycled to the cell feed. One kg of iodine will yield 1.55 kg of KIO₃. The total capital outlay for a 30 Tons per year plant has been estimated in India to be approximately \$200,000. Further technical details can be obtained from the National Research Development Corporation of India, New Delhi, India.

For salt iodization, potassium iodate should conform to the following standards:

1. Physical Appearance	: White to almost white crystalline powder
2. Particles retained on 100 mesh B.S. sieve	: 5% max, w/w
3. Solubility	: Soluble in 30 parts water
4. Reaction	: A 5% solution in water shall be neutral to litmus
5. Iodine (I ₂) Max w/w	: 0.005%
6. Sulphate, Max w/w	: 0.02%
7. Heavy Metals (as Pb)	: Less than 20 ppm
8. Iron	: Less than 10 ppm
9. Bromate, Bromide, Chloride and Chlorate Max % w/w	: 0.5
10. Insoluble matter, Max % w/w	: 0.5
11. Loss on drying at 105 °C Max % w/w	: 0.5
12. Assay (on dry basis)	: 99.0% potassium iodate min
13. Packing	: Plastic bag or paper drums with closed seal 50 kg

Table 7.6 - Quality specifications for potassium iodate

8. SALT IODIZATION TECHNIQUES

Iodine is added as potassium iodate to salt after refining and drying and before packing. Iodization can often be linked with existing production and/or refining lines. This can be done by adding a solution of potassium iodate to the salt (wet method) or by adding dry potassium iodate powder (dry method). In the wet method, potassium iodate is first dissolved in water to make a concentrated solution. This solution can be either dripped or sprayed on the salt at a uniform rate. In the dry method, the potassium iodate is first mixed with a filler such as calcium carbonate and/or dry salt and the powder is then sprinkled over the dry salt. In both methods, thorough mixing of the salt after the addition of the potassium iodate is necessary to ensure even penetration of the potassium iodate. If the mixing is insufficient, some batches of salt will contain too much iodine and others too little.

Dry Mixing

The potassium iodate is mixed with an anti-caking agent like calcium carbonate, tricalcium phosphate, or magnesium carbonate in a ratio of 1:9. One part of this stock mixture is then mixed with 10 parts of salt to form the "premix" which is introduced onto a screw conveyor at a constant rate (Fig 8.1). Salt is also introduced onto the conveyor and mixing takes place as the material moves through. This process is suitable for fine and even-grained salt with a grain size of less than 2 mm. It has been adopted in several countries of South and Central America including Argentina, Bolivia, Guatemala and Peru.

In China, a unique and compact type of dry mixing machine has been developed. Essentially, it consists of an inclined screw conveyor with a feed hopper at its lower end through which salt is fed (Fig. 8.2). A slide within the feed hopper controls the rate of salt addition. A premix of KIO_3 with salt at an approximate ratio of 1:2000 is prepared separately and fed onto the bulk salt at a controlled rate by a rotating arm within a conical feeder, or by a screw within the screw feeder located close to the salt feed hopper above the conveyor. The salt and premix are mixed as they move up the screw conveyor and the desired content of iodine in the salt is achieved. The mixture is then homogenized by passing through a roll crusher or pin mill that grinds it to a uniform size of 1-3 mm. After crushing, the iodized salt is passed through a second inclined screw for further mixing before packing.

Drip Feed Addition

This process is commonly used for iodization of salt crystals. The crystals are manually fed into a hopper that discharges at a uniform rate onto a belt conveyor, about 35-40 cm wide and 5.5 m long inclined at a slope of about 20 degrees (Fig. 8.3). The conveyor is equipped with a tensioning device. The feed hopper has a capacity of about 300 kg and the rate of salt flow onto the conveyor is controlled by a slide valve. Flexible rubber curtains on three sides shape the salt into a narrow band 10-12 cm wide and 2 cm deep on the conveyor belt and prevent it from spilling over the edge. The KIO_3 solution is stored in two 200 litre polyethylene stock tanks with discharge valves at the bottom to permit the filling of two 25 litre feed bottles, mounted to ensure a continuous circulation of solution from the main tank to the feed bottles. Thus the solution continuously drips at the desired rate onto the salt crystals. The iodized salt falls into a discharge hopper for collection in bags. For continuous operation the hopper should have a twin spout with a diversion valve. Experience has shown that a capacity of 5 tons per hour is ideal for a drip feed system, which requires only a low pressure head to maintain the required flow rate. This method is used in some Asian countries, for example, Indonesia. The drip feed system is simple and cheap and is often used for iodizing moist crude salt crystals and even refined powder salt.

In a simplified system used in India, the drip system is introduced into the feed point of a salt grinder. The drip feed system followed by grinding often yields consistent iodate dispersion (Fig. 8.4).

Spray Mixing

Often, iodization is to be integrated with existing salt production and refining systems. Typically salt slurry from a thickener is dewatered in a centrifuge and then dried in a rotary or fluid bed drier. Into this system a sensor installed on the thickener can send a signal to the solution dosing pump that sprays iodate solution at a rate proportional to the flow rate of solids to the centrifuge. (Fig. 8.5)

In more conventional operations where refining equipment is not available, salt iodization plants will need to be established. Salt in crystal form is crushed to a coarse powder in a roller mill and manually fed into a feed hopper fitted with a wire mesh screen or grating at the top to prevent large lumps of salt from falling into it (Fig 8.6). A second shaft with four plates is fitted in the outlet of the hopper and regulates the flow onto an inclined conveyor belt. Both these shafts are driven by a variable speed drive system and the rate of rotation is adjusted to give the required throughput.

The sheet of salt discharging from the belt into the spray chamber receives a fine atomized spray of potassium iodate solution from two nozzles, at a pressure of 1.4 kg/cm². The spray nozzles are designed to deliver a flattened spray that spreads over the entire width of the salt stream. The concentration of solution and the spray rates are adjusted to yield the required dosage of iodate in the salt. The iodate solution is kept under pressure in two stainless steel drums, each of about 80 litres capacity. The pressure in the drums is maintained constant by an air compressor with a regulator. The salt with added potassium iodate falls into a screw conveyor 20-25 cm wide and 2.5-3.0 m long. Travel through the screw provides uniformity of mixing. The screw conveyor discharges into twin outlets where bags are kept ready for filling. The spray mixing plant can be powered by electricity or diesel engines. All the parts coming into direct contact with salt are made of stainless steel, to minimize corrosion. The plant can also be made mobile for operational convenience. A spray mixing type of plant built to UNICEF specifications operates at 6 tons/hour or about 12,000 tons per year. This method is being increasingly preferred in Asia, South America, and Africa.

The standard spray-mixing plant configuration described above has been simplified with the elimination of the belt conveyor and making the screw conveyor inclined (Fig 8.7).

A batch-type version (Fig 8.8) has been developed in India for small manufacturers who cannot afford or do not need continuous spray mixing plants. It consists of a ribbon blender fitted with an overhead drip or spray arrangement. A pre-weighed quantity of salt is fed into the blender. The blender is operated and a prefixed quantity of iodate is sprayed through overhead nozzles using a hand pump or compressor as mixing proceeds. After iodization the batch is discharged and packed.

Tables 8.1- 8.4 describe operating features of spray mixing plants under different conditions by KIO₃ dosage.

The blenders are powered by suitable motors or diesel engines. The rotation is reduced through a suitable gear box to give a speed of 20-30 rpm. The speeds and power requirements of blenders of different capacities are given below:

Batch Capacity	Power drawn	Required power
125 kg	2.2 KW	3 HP
250 kg	3.7 KW	5 HP
500 kg	3.7+1.5* KW	5+2* HP

*For vertilift conveyer to feed salt to blender. In smaller blenders, salt is fed manually.

Table 8.1 - Speed and power requirements of batch mixing process

The quantity of salt that can be produced by a batch blender is determined by the cycle time and batch capacity. Assuming:

- * Loading: 3 min;
- * Mixing: 10 min;
- * Unloading: 2 min; and
- * Slack: 5 min;

- * Total: 20 minutes,

there will be 3 cycles per hour. On this basis the following are the daily 8 hour iodization capacities:

Batch Capacity	Production capacity/hr	Production capacity/shift	Production capacity/yr (250 days)
125 Kg	0.375 ton	3 ton	750 ton
250 Kg	0.750 ton	6 ton	1500 ton
500 Kg	1.500 ton	12 ton	3000 ton

Table 8.2 - Production capacities of batch mixing process (single shift basis)

The capacity will obviously increase if the blenders run for longer hours or if more batches are produced hourly.

This method is simple to operate in the capacity range 0.5-3 tons/hour. It is already being used in India, Peru, Vietnam, and may also be applicable in several other countries needing small iodization plants close to salt production sites or at strategic points in the distribution network.

The spray system atomizes the iodate solution and disperses it uniformly on the salt crystals, thus ensuring much more uniform mixing when compared to the drip feed system for all kinds of salt. The equipment requirements for the spray system and their maintenance are a little more elaborate.

Iodization level	g KIO ₃	Strength of KIO ₃ solution		
		10 g/L	20 g/L	30 g/L
20 ppm	100	10.0	5.0	3.3
30 ppm	150	15.0	7.5	5.0
40 ppm	200	20.0	10.0	6.7
50 ppm	250	25.0	12.5	8.3
60 ppm	300	30.0	15.0	10.0
70 ppm	350	35.0	17.5	11.7
80 ppm	400	40.0	20	13.3
90 ppm	450	45.0	22.5	15.0
100 ppm	500	50.0	25.0	16.7

Table 8.3 - Amount of KIO₃ solution in L/hr for 5 ton/hr spray mixing plant

Batch Capacity	Strength of KIO ₃ solution		
	10 g/L	20 g/L	30 g/L
125 Kg	625	313	208
250 Kg	1250	625	416
500 Kg	2500	1250	833

Table 8.4 - Quantity of KIO₃ solution required (ml) to introduce 50 ppm in a batch of salt

Comparison of methods

Table 8.5 compares the different methods, showing their relative advantages and restrictions. Dry mixing of salt with KIO₃ is possible only if the salt is dry and finely ground. Otherwise the KIO₃, having a finer particle size and being heavier than salt, will settle at the bottom of the container. This method is therefore not recommended for the unrefined coarse salt that is commonly used in developing countries.

The drip-feed system is the simplest and cheapest. It is suitable for coarse salt with uniform particles of a size up to 1 cm and a moisture content of up to 5%. However, when the particle size of the salt is very fine (less than 2 mm), the drip feed system is not suitable because it does not disperse the iodate solution with sufficient uniformity. In such cases, the spray-mix method is better because it atomizes the iodate solution and sprays it as a mist, thus mixing it uniformly with the salt. The spray-mix method is also preferable to the drip feed system when the salt varies in particle size and moisture content, as frequently occurs when the iodizing plant receives salt from a number of different sources.

Annex 5 gives specifications and prices of several types of salt iodization machines available through UNICEF.

Method Criterion		Drip	Spray	Dry Mix
S a l t T y p e	Refined powder, dry	++	+++	+++
	Unrefined powder, dry	++	+++	+++
	Unrefined powder, moist	++	++	++
	Unrefined crystals, dry	++	++	+
	Unrefined crystals, moist	+	++	+
C o s t	Capital	Medium	Med	High
	Operating	Medium	Medium	High
	Cost to consumer	Medium	Medium	High

+ Poor ++Fair +++ Good

Table 8.5 - Comparison of principal salt iodization methods

The choice of salt iodization method depends upon the conditions prevailing in a particular location. The less developed countries frequently are hampered by salt of uneven purity, humidity, and unreliable packing material, and for them the preferred method will usually be crushing the salt and iodizing it by spray mixing with KIO_3 . Small producers should either set up individual small batch iodization plants or form co-operatives for centralized iodization and packing. Iodization units portable from one field to another should also be considered.

Simple Methods for Salt Iodization at the Village Level

Salt iodization, like most industrial procedures, is most efficient when operated on a large scale, as described in the previous methods. A large producing unit can use sophisticated equipment, optimize employee activity, consolidate laboratory and other quality control measures, and facilitate packaging and transport. Each of these steps promotes greater efficiency, reliability, and economy. Since salt production is usually concentrated at a limited number of sites, most iodization interventions will be located near these sites.

Despite these advantages of the type of salt plants described in the preceding paragraphs, simple salt iodization at the village level is occasionally valuable, and will be considered briefly here.

Perhaps the simplest method is the dry mixing of sodium chloride with KIO_3 , or with KI. For an iodization level of 50 ppm (1:20,000), one needs to add 84 mg of KIO_3 for each kg of sodium chloride. This is best added slowly while the dry sodium chloride is being mixed in a bowl. The amount of KIO_3 being added is minuscule compared to the volume of the salt, so that even with sustained manual mixing and pouring back and forth, the distribution of the KIO_3 within the sodium chloride will always be somewhat uneven. The salt and KIO_3 can be mixed simply with a large wooden spoon, and including pouring back and forth between two vessels if feasible. This process is both inefficient and unreliable, and we would not recommend it except as a temporary measure when no other means of achieving iodization is available. Since the amount of KIO_3 is so small, it will have to be supplied in pre-weighed packets because accurate balances will virtually never be available in villages choosing this approach.

Other methods use manual spraying of a KIO_3 solution on to salt as it is being stirred by hand. The spray bottle approach permits greater dispersion of the iodate than is achieved with manual dry mixing. In a system developed by Professor Romsai Suwanik in northern Thailand, 24 grams of KIO_3 (containing 14.2 grams iodine) are dissolved in 725 ml of distilled water, to give a concentration of 2 mg iodine/ml. For spraying, 60 ml of this concentrated KIO_3 solution are diluted to 240 ml in a spraying bottle and spray mixed by hand with 24 kg of salt in a plastic basin. The uniformity of distribution of iodine throughout the salt in this procedure depends on the evenness of the spraying and the vigour of the mixing.

A larger scale manual procedure has also been developed and applied in the north of Thailand by Professor Romsai. This uses a spray mixing table which houses two large salt-containing basins that can be emptied from the bottoms. Spray bottles are hand operated at the rate of 50 kg in ten minutes or 300 kg/hour. By this technique, about 18 tons of salt can be iodized in 20 working days. The equipment expense is minimal, consisting only of the table, costing about US \$50. As in the procedure described above, the success of this procedure will depend on the evenness of spraying and vigour of mixing of the salt.

These village methods cost virtually nothing in equipment and put the village in direct control of its own salt iodization. These advantages must be balanced against the difficulty of achieving even distribution of iodate in the salt, the general labour inefficiency of these small operations, and the dependence on constant reliable operation. These programs are probably best viewed as an inexpensive way to initiate an iodization program and obtain community interest, in preparation for a more conventional and sustainable salt iodization program over a larger geographical area.

Building Requirements

Iodization equipment can often be housed in an existing salt storage warehouse which can be done by reallocating the space available or by adding a separate room. If, however, a new building is

to be added, it should be done on a very functional basis. For a 5 tons/hr plant working 8 hours a day, the daily requirement of salt is 40 tons. Assuming a raw salt stock of 15 days and a finished product stock of 15 days, the total storage capacity should be 1200 tons. On this basis, the building area is estimated in Table 8.6. A tentative lay-out for an iodization station is proposed in Fig 8.9.

Purpose	Space requirement (m ²)
Salt storage, 1200 tons (4 ton/m ²)	300
Alleyways and passages (add 30% of storage)	90
Iodization plant and processing room	100
Office	16
Stores for spares, etc.	16
Switch room	6
Laboratory	9
Bay for loading and unloading	150
TOTAL AREA REQUIRED	687 m²

Table 8.6 - Estimated building area for 5 ton/hr, single shift plant

Operations Control - Spray Mixing Process (batch and continuous)

The success of the spray-mixing process depends on ensuring a steady and uninterrupted flow of salt from the conveyor belt. The spray should cover the entire width of the sheet of salt falling into the chamber. The movement of the belt must be even and the speed uniform. The belt tension should be checked to ensure that the throughput rate does not fluctuate owing to belt slippage. Care should be taken to see that the air pressure is maintained at the desired level (25 psi).

The KIO_3 solution should be prepared by dissolving the pre-weighed quantity of iodate powder in water (preferably distilled) and filtering it through a fine cloth to avoid clogging the nozzles with any undissolved crystals and extraneous matter, and then analyzed to check the concentration. For a quick check, the concentration can also be measured with a precision hydrometer. An iodate solution concentration of 25-30 gms per litre is recommended. Evaporation of the iodate solution and crusting in the nozzle present the danger of clogging the nozzles. It is therefore advisable to check the nozzles every day and to clean them by immersion in boiling distilled water for 30 minutes whenever necessary, or at least once a week. The nozzles may have to be replaced once a year.

The chemist should collect samples of iodized salt at regular intervals as it flows out of the chutes. He should analyze them immediately for iodine content, and advise the plant operator to take corrective measures, as needed, by adjusting the flow of salt/spray. This analysis must be very prompt to permit effective control of levels.

Iodized salt should be collected into bags directly as it flows out of the chutes instead of allowing it to fall onto the ground, because any moist crystals may pick up dust and dirt.

Maintenance of Iodization Equipment

All parts of the plant that are not stainless steel should be regularly cleaned with rags to brush away salt particles and given a coat of anti-corrosive paint periodically as outlined below.

Maintenance painting is necessary to protect equipment of mild steel (carbon steel) from saline corrosion. This involves surface preparation and coating. Surface preparation and application are as important to the successful life of a coating as the coating itself. Without proper surface preparation, the most resistant coating will fail in service. After hand cleaning the steel of scale, dirt and grease, the surface has to be sand blasted to near white metal (NACE (National Association of Corrosion Engineers) No. 2 finish). Where the surface is small, it has to be thoroughly scraped with a steel wire brush.

For coating, a paint based on epoxies, neoprene chloroprene, chlorinated rubber, polyvinylidene chloride, or polyvinyl chloracetates is recommended. The proper coating procedure begins with two primer coats, including a first coat of 2-component cold-curing epoxy resin-based primer with zinc chromate, colour grey and a second coat of the same primer, but of grey colour with bluish tinge, to give a total thickness of two coats not less than 80 microns, followed by two final coats of two-component cold-curing epoxy-based paint.

All the bearings should be well greased so that the operational efficiency of the plant is maintained. Jammed rollers and slow-moving belt conveyors will give uneven iodization.

All electrical connections and control points should be periodically checked to prevent short-circuiting from corrosion.

9. DEVELOPMENT AND STATUS OF SALT IODIZATION PROGRAMMES

Historical background

The use of salt as a vehicle for iodine began in the 1920's in the USA and Switzerland. This followed the pioneering studies of Dr. David Marine in Akron, Ohio, USA in the preceding decade, which showed that administration of iodide tablets over several days twice a year produced a dramatic decrease in goiter in adolescents. The salt industry found that it was relatively easy to add iodine at a final stage in the processing of salt before packing. The concept gained ground and soon most salt companies in the USA, Canada, Australia and certain European countries like Switzerland began iodizing their salt. The practice continues today.

When the concept of salt iodisation was transferred to developing countries, it was believed that the problem could be solved with the same ease. Therefore, by the late 50s, salt iodisation programs had been initiated in several Central and South American countries. While some countries in that sub-continent showed remarkable progress in combating the problem, bottlenecks persisted in others. In certain countries in Central America, the problem was successfully eliminated but subsequently recurred when government commitment to the programme and monitoring slackened. By the early 1990's, countries with logistic constraints like Ecuador and Bolivia systematically identified and overcome these problems.

In Asia, although action was initiated in the '50s and '60s, progress was minimal until the late 70s. Subsequently, with increasing awareness of IDD and its consequences, several governments reappraised their programmes. This led to a systematic identification of the bottlenecks and streamlining of iodisation programmes in several countries. Since the early '80s, China has implemented a successful program targeted at the endemic areas covering about 300 million people and recently took a decision to expand the programme to cover the entire country. India adopted a policy of universal iodisation of all salt in the country in 1984. Currently, over 500 million people living in the endemic regions of India are receiving iodised salt. Indonesia faces constraints in its salt iodisation program owing to a large number of scattered small salt producers in its islands. Several other countries like Bangladesh, the Philippines and Thailand are in the process of establishing iodisation facilities in all their salt processing units. Bhutan's salt iodisation program has successfully overcome an extremely severe iodine problem in the entire country.

In Africa awareness has been fairly recent, less than six years. Subsequently, salt iodisation programs have been strengthened or initiated in Ethiopia, Kenya, Tanzania, Nigeria and Cameroon. Several other countries including Zaire, Zambia, Ghana, Zimbabwe and Malawi are planning control programs. In Sub-Saharan Africa several countries do not produce their own salt and rely partly or wholly on imports. This has prompted the development of a regional strategy to ensure that salt is iodised at the production sources in South Africa, Namibia, Mozambique, Eritrea, Sudan, Ghana and Senegal. Countries in different regions of the continent are also cooperating to establish common standards for salt purity, iodine level, packaging and labelling. The status of iodization programmes in different parts of the world is summarized in Table 9.1.

Region	Programme status
North America & some West European countries	Ongoing & Effective
Other West European countries	IDD problems persist. Need for legislation to ensure iodization.
South & Central America	Effective in several countries; problems persist in others where monitoring is weak.
South and South-east Asia including China	Several countries moving towards universal iodization; streamlining and monitoring a priority.
Middle East	Assessment completed and programmes initiated in several countries
North Africa	Effective in several countries. Problems persist in others
Sub-Saharan Africa	Regional strategy being implemented with standardised specifications and regulations. Salt industry reorganization and modernisation in West Africa a priority
Eastern Europe & Central Asia	Salt situation not fully assessed; need for universal iodization programmes in several countries.

Table 9.1 - Status of salt iodization in different regions of the world

Constraints hampering salt iodisation programmes

Today salt iodisation programs are working well in several countries and have become part of the salt production and distribution system to such an extent that monitoring is virtually unnecessary, but bottlenecks persist in several developing countries, causing programmes to fail or be only marginally effective.

A review of the salt production and distribution systems in various developing countries shows common patterns and constraints in implementing salt iodisation programs. These similarities provide a basis to assess, plan and implement new programmes or strengthen existing programs. Some of the common constraints are:

- Inadequate awareness on the part of policy makers, the salt industry and the general public of the magnitude of the problem and its alleviation through salt iodisation;
- Multiplicity of salt production sites and diversity of types of salt in the market;
- Primitive methods of salt production, leading to poor salt quality, which contributes to moisture absorption and leaching of iodine from the salt;
- Inadequate packaging, aggravating iodine losses during transport, handling and storage;
- Erratic salt distribution patterns with inadequate distribution of iodised salt in areas where transportation is deficient;
- Internal infiltration and external contraband of uniodized salt;
- Iodised salt sold at a higher price than uniodised salt; a price differential compels the poor and needy to choose the more inexpensive salt;
- Non-compliance with iodisation laws; the legal provisions on iodisation often do not include salt for animal consumption; and
- Inadequate program coordination, monitoring, and attention to the salt industry and to aspects of production, transportation, iodisation, packing, distribution and marketing.

These constraints are grouped below as problems of: awareness; production; marketing; iodine fortification; economic factors; programme organization, coordination and management; and existing policy. Under each category, the important criteria related to each constraint are listed.

A. Awareness and consumer attitudes

1. Under-estimation even by medical professionals of the prevalence and severity of IDD, especially the magnitude and consequences of neonatal hypothyroidism.
2. Inadequate appreciation, at decision making levels and by the public at large, of the extent and severity of IDD and its consequences for both individual and social development, and the feasibility and comparatively low cost of preventive measures.
3. Lack of understanding among programme planners and implementors of the need for maintaining impeccable standards in carrying out the otherwise simple tasks of proper salt iodization, bagging, storage, transport and distribution.
4. Erroneous perceptions about which sector or agency would be most appropriate as the lead agency to direct, supervise and control preventive programmes
5. Lack of recognition of the need for consumer education to promote the consumption of iodized salt wherever unfortified salt is simultaneously in the market (often at a lower price).
6. Inadequate awareness at the global level of the extent severity and consequences of IDD and of the unprecedented opportunities to control this problem effectively.

B. Production, quality, and iodine retention

1. Existence of too many small, unorganized salt producers of limited means
2. Primitive technology of salt production and processing
3. Lack of technical and financial assistance, especially to small producers
4. Absence of proper facilities, equipment and supplies for processing, storage, handling and transport of salt
5. Patterns of ownership of salt fields and mines, often involving monopolistic and absentee control
6. Inadequate control of iodization quality at the factory.

C. The iodization process

1. Lack of organization in the creation of socially, economically and technically adequate systems of salt iodization
2. Poor technical knowledge of salt preparation, processing and iodization
3. Producer resistance to increased production cost and to the industrial process itself.
4. Excessive humidity and contamination of salt

5. Limited access to technical and financial assistance for iodization, especially for small producers
6. Inadequate preventive maintenance, and repairs or replacement of obsolete equipment

D. Packing, storage and marketing

1. Lack of information on existing salt trade patterns and feasibility studies to alter existing origin/destination flows.
2. Failure to carry out studies on the production and marketing of salt not carried out
3. Producer resistance to increased production cost and to the industrial process itself.
4. Excessive humidity and contamination of salt

E. Economic Factors

1. No definition of the financial mechanisms required to maintain the programs; even when these are specified, they have not been fulfilled
2. Disproportionate increase in the price of iodized salt
3. Black market for uniodized salt
4. Sale of uniodized cattle salt for human consumption

These considerations are a good starting point to develop a programme, but it is necessary to bear in mind that each country has its own unique salt production and distribution system as well as constraints. To this extent, programmes have to be country-specific and need to incorporate tailor-made solutions. While these issues have to be addressed by the individual governments and local industry, external technical and/or financial inputs are occasionally needed.

Constraints in salt production and distribution

Key considerations include:

- salt producers are often a heterogeneous group consisting of private companies, cooperatives and individuals who may be operating outside any legal or administrative framework;
- multiple small salt producers and erratic distribution patterns making management of the program difficult;
- primitive methods of production which lead to poor salt quality; for example, visible impurities prompt householders to wash salt before cooking, resulting in the loss of virtually all iodine;
- inadequate packaging, for example in jute rather than high-density polyethylene, which aggravates iodine losses during transport, handling and storage.

While it is possible to iodise most kinds of salt and iodisation can be done on a very small scale, an effective programme will require good quality control procedures. Salt producers or refiners need to be trained in correct iodisation procedures, quality control and maintenance of records that will be accessible to government inspectors. In countries that already have a modern salt industry that provides most of the salt, iodisation is likely to be simple, straightforward, and acceptable, and will involve only marginal cost increases. In countries where salt is still produced by numerous artisanal producers, iodisation with the necessary quality control and supervision will be much more difficult. It will be more effective to advocate and support the modernisation of the salt industry so that a relatively small number of large producers or refiners compete to produce good quality packaged salt rather than to provide iodisation facilities to hundreds of small producers. Small producers can be encouraged to participate in cooperatives with a central refinery that iodises, packages and distributes their salt. Such group-operated units can be well managed and monitored. There are many advantages in refining and marketing salt in small (1 kg) moisture-proof packets that are clearly labelled as being iodised. In many developing countries with fast improving socio-economic status, refined packaged salt is gradually gaining popularity. In countries with virtually no domestic salt production and almost all salt imported, the ideal strategy will be for salt to be properly iodised in the country of origin. Compared to the costs of packaging and transportation, the additional cost of iodisation should be low. These costs might be absorbed by consumers or through more efficient and competitive purchasing.

10. QUALITY CONTROL AND MONITORING OF SALT-IODINE LEVELS

Monitoring the level of iodine in the salt is important in several respects:

- i) To ensure that salt manufactured or imported into a country meets specifications - a legal requirement;
- ii) To ensure that salt that reaches the consumer contains iodine to ensure prevention of IDD - physiological requirement;
- iii) To verify that laxity has not crept in at the production or importer level
- iv) To ensure sustainability of the programme, and any deviation from prescribed levels should be reported at once and action taken;
- v) Continuous monitoring of iodine levels is one of the best and simplest ways of monitoring the entire IDD elimination programme when salt iodization is the intervention strategy; and
- vi) Failure to monitor properly has been the major cause of breakdown of IDD control programmes in the past.

Methods of measuring iodine in salt

Two techniques for measuring iodine levels in salt can be used:

- i) *Standard titration method* - conducted in laboratories. This method is described in Annex 1. A given amount of salt is treated with concentrated sulphuric acid, which liberates iodine. The free iodine is titrated with sodium thiosulphate, using starch as indicator. The titration result provides an accurate quantitative estimate of the iodine level in the salt. This method is preferred for accurate checking of salt batches produced in factories and, in cases of doubt, for resolving disputes. The laboratory equipment required for this test is not complicated or expensive (total about \$ 1000) and is available as a standard kit through UNICEF Supply Division, Copenhagen (See Annex 2).
- ii) *Rapid-test kits* - These consist of bottles of starch solution (stabilized) of which one drop is placed on the salt. The intensity of the blue colour that develops indicates the approximate iodine level. A single ampoule of reagent (10 ml) will allow about 80-100 tests. A box of 3 ampoules costs \$0.40. Details of kits are given in Annex 3.

The role of the tests is as follows:

- i) **Titration method:** This method is used when great accuracy of the iodine level is required. It is used in cases of disputes or to do operational research to determine, for instance, the concentration of iodine in salt at various levels in the distribution system.
- ii) **Spot testing:** It is proposed that this method be carried out routinely, for instance, at each district headquarters. This testing would normally fall under the responsibility of health inspectors whose duties include testing quality of food stuffs. Samples that are found to be sub-standard should be sent to the laboratory at a central level for checking. The test could also be

carried out on salt as it is iodized and before it is packed. It could also be used to check sacks at the entry points of salt into a country.

Hence a regular system for salt monitoring must be instituted to periodically check salt-iodine levels from production to consumption. The overall responsibility for quality control within the country should be with the concerned Ministries (Ministries of Industry for production level and Ministry of Health for consumption level). Criteria for assuring the adequacy of programmes (based on the recommendations of the Joint WHO/UNICEF/ICCIDD Consultation) are summarized in Table 10.1. The procedure for monitoring iodine levels in salt should be:

Factory level: The manufacturers' level is the most important level for monitoring. The manufacturer should conduct his own monitoring. Hourly testing of iodine levels in salt during production is recommended, preferably by titration in a lab or at least with a testing kit that shows some sensitivity to colour change. Salt producers should be urged to hire such a person specifically for quality control. External monitoring of production level quality control should be done by government officials (Ministry of Health or Standards Bureau) to substantiate the accuracy of the manufacturer's records. Weekly (or later, perhaps monthly) external monitoring should be done on a random unannounced basis. If the salt is not adequately iodised at production level, the batch of salt should not be distributed and should be re-iodized.

Distributor and wholesale level: The major distributors should be sensitised and provided with rapid-test kits to check the presence of iodine in the salt before it is released for retail sale. Regular monitoring at three-monthly intervals is advisable. District or county health departments should be notified of deficiencies.

Consumer level: The overall responsibility for quality control peripherally, inside the country, should be vested in the Ministry of Health through its Primary Health Care Department and regional/provincial and district health departments in particular, the public health inspectors or nurses at the district level (note: a district is here used to designate the smallest administrative level at which all the major government departments are represented). The aim is to verify that adequate concentrations of iodine are attained in salt, primarily at the consumer level; and if the level is inadequate there, the concentration at higher levels of the distribution system (retail and wholesale) are to be verified in order to determine the level at which excessive losses are occurring.

Process Indicator	Criterion of Adequacy
<p>A. Factory level</p> <ol style="list-style-type: none"> 1. Percent of food grade salt claimed to be iodised 2. Percent of food grade salt effectively iodised 3. Adequacy of internal monitoring process 4. Adequacy of external monitoring process* 	<p style="text-align: right;">100%</p> <p style="text-align: right;">≥90%</p> <p style="text-align: right;">≥90%</p> <p>10-12 monthly checks per producer per year</p> <p>Corrective action systematically taken within 3 hours in 90% of cases, following the lot quality assurance methodology</p>
<p>B. District and Consumer level</p> <ol style="list-style-type: none"> 1. Percent of monitoring sites with adequately iodised salt <ol style="list-style-type: none"> i) households (or schools) ii) district headquarters (including major markets) 2. Adequacy of monitoring process** 	<p style="text-align: center;">Adequate in 90% of samples</p> <p style="text-align: right;">90% or more</p>

**Monitoring undertaken in 90% of counties in each district, at both household and district level

Table 10.1 - Criteria for assessing adequacy of salt iodisation programmes (source: Joint WHO/UNICEF/ICCIDD Consultation on Indicators for IDD Control)

Procedures

A. Factory Level:

For indicators A1 and A2 in Table 10.1, a list will be compiled of individual producers or importers of salt destined for human consumption who process more than 500 tons of salt per year and who are effectively iodizing all salt distributed to national standards.

For indicators A3 and A4, adequate monitoring is defined through two processes:

- i) by encouraging all importers and producers handling over 500 tons to establish an internal system of monitoring and record keeping that can be examined by Government inspectors; and

- ii) by Government inspectors taking a minimum number of samples of salt from the factory or import point on a monthly basis and subjecting these to standard laboratory analysis. At least one sample should be taken monthly from each factory/importer.

B. Community and district level

Monitoring of salt samples at the consumer level can be based on markets, households or school surveys.

Public health officers (e.g. health inspector or nurse) in all districts of the country should be trained to visit 4 houses in each of 10 remote villages and test samples of salt on the spot with a rapid test kit once every six months. (Within each village four low-income households are selected, one in each sector of the village as defined by lines running north to south and east to west in the village.) The district should be divided into remote and non-remote areas based on criteria of distance and accessibility. If IDD are known to be more endemic in a particular segment of the district, tests should be concentrated on villages in that segment. A new selection of villages is made every six months. The salt tests would normally be done in these villages during another visit e.g. for purposes of immunization programmes. In situations where this is not possible in all districts immediately, such spot checks should be made in the more severely IDD-affected districts or regions, and in districts or regions where more than 10% of the salt is suspected to be provided by small producers or importers handling less than 500 tons per year, who would not be monitored in the procedures indicated in Part A.

From the point of view of enhanced community participation, it is also advantageous to use the primary school system. School surveys may also be the easiest to organize. If kits can be supplied to school teachers, the latter could be trained to undertake the tests in villages, selected as already indicated, and pupils could bring salt samples from their homes for testing. For schools with an enrolment of 100 to 1000 students, at least 35 salt samples will have to be collected and tested; 4 or more low iodine samples indicate that more than 20% of the population may be using inadequately iodised salt.

The testing of samples at the district level should be carried out regularly, preferably with every new arrival of salt. At least 40 samples per 6-month period should be tested. At the consumer level, monitoring by local persons can also serve the communications component of the salt iodization programme by generating more discussion and awareness.

C. Additional monitoring needs at intermediate levels

If the checks at the district level show consistently inadequate levels of iodization, spot checks should be made at successive higher levels to identify the level at which excessive losses occur.

In larger countries or in situations where transportation results in a long lag between production and consumption, regular monitoring at intermediate levels (distributor and wholesaler) may be needed, e.g., at three monthly intervals, to provide more rapid feedback and to indicate whether the salt iodine concentration is adequate at these levels.

Follow up

Where iodine levels are found to be consistently unsatisfactory, remedial measures must be identified and implemented, as follows:

i) Steps to reduce losses e.g. during transport (excessive exposure to weather)

- reduce transport time
- reduce exposure to light/moisture
- better packaging

ii) Raising the level of iodization required by law

Administration

Salt monitoring must therefore be under the general management of a National IDD Technical Committee or equivalent body. That Committee should take into account also the findings of biological assessment, especially urinary iodine analysis, in an adequate sample population, before proposing or making any changes in the level of iodization.

Because of the important role of salt industry personnel for salt iodine monitoring at production level, and of health inspectors for salt iodine monitoring in the periphery, it is advisable to ensure adequate training and motivation for these key players in monitoring and follow-up procedures. The salt industry and the environmental service of the Ministry of Health should be represented in the National IDD Committee.

(Chapter 1)- A woman and her child from an iodine- deficient area. Her goiter is a result of the iodine deficiency, and children born to iodine-deficient mothers are at risk for mental retardation (photo D. Havron)

(Chapter 17) - Sheep with goiter in a region of iodine deficiency. The deficiency in animals has consequences similar to those in humans and

impairs farm productivity and the rural economy (photo E. Cabezas)

(Chapter 1) - An adult cretin from an area of iodine deficiency. She has gross mental retardation, deafness, and short stature, all manifestations of severe iodine deprivation during early development.

(Chapter 5) - Salt production in a solar field. Water evaporates from salt solution, and the dried salt is harvested.

(Chapter 5) - A rock salt quarry, showing large lumps of salt.

(Chapter 6) - A plant for refining salt by hydromilling.

Chapter 8) - A simple plant iodizing salt by the drip feed method.

(Chapter 8) - Integration of the iodization process into an existing salt plant

(Chapter 8) - A stationary iodization plant,
using continuous spray mix

(Chapter 8) - A mobile iodization unit, by
spray mix

(Chapter 8) - A simple small portable iodizing
unit

(Chapter 8) - A simple stationary salt
iodization unit suitable for use at the local level
(photo: Romsai Suwanik)

(Chapter 8) - An entirely manual iodization apparatus, with hand spray of an iodate solution, used at the local level (photo: Romsai Suwanik).

(Chapter 8) - Simple iodization in a village school, using hand spraying of iodate solution. The entire operation is carried out by schoolchildren under the supervision of the head master, and provides iodized salt for their village.

(Chapter 10) - Equipment for laboratory testing of iodine content in iodized salt.

(Chapter 10) - Results of testing with the field kit. The dark spot in the salt on the right shows

iodine content, while the salt on the left gave no color, indicating no iodine.

(Chapter 11) - A salt packaging machine

(Chapter 11) - An example of poor packaging and storage of salt. Such conditions can produce large losses of iodine from iodized salt.

11. PACKAGING, STORAGE AND DISTRIBUTION OF IODIZED SALT

Salt Packaging

The main objective of any salt iodization program is to ensure that salt contains the recommended amount of iodine at the time of consumption. The retention of iodine in salt depends on the iodine compound used, the type of packaging, the exposure of the package to prevailing climatic conditions and the period of time between iodization and consumption. Iodized salt is often consumed in areas far removed from the salt producing centres and it is important to ensure that it ultimately reaches the consumer with the specified level of iodine. Since salt is hygroscopic at relative humidities above 76%, iodized salt that is improperly packed and transported over long distances under humid conditions attracts moisture and becomes wet, carrying the iodate to the bottom of the bag. At a humidity lower than 76%, salt can release surface moisture, and this also may result in some iodine loss. If the bag is porous, the iodine compound can leak so that little or no iodine is left in the salt by the time it reaches the consumer.

To avoid these losses the following precautions should be observed:

1. Iodized salt should be packed in airtight bags of either high density polyethylene (HDPE) or polypropylene (PP) (laminated or non-laminated) or LDPE-lined jute bags (Grade 1803 DW jute bags lined with 150 gauge polyethylene sheet). In many countries this may call for a major switch from conventional packing materials made of straw or jute. The cost of adding extra iodine to compensate for its loss from cheaper packing must be weighed against the cost of switching to a more expensive packing material.
2. Bulk packing units should not exceed 50 kg (in accordance with the International Labour Organization (ILO) conventions), to avoid the use of hooks for lifting the bags.
3. Bags that have already been used for packing other articles such as fertilizers, cement, chemicals, etc. should not be re-used for packing iodized salt.
4. The distribution network should be streamlined so as to reduce the interval between iodization and consumption of salt.
5. Each bag should be marked with the following legend (Table 11.1) to identify the contents for monitoring purposes:

IODIZED SALT
1. Name of the manufacturer: _____
2. Month/Year of manufacture: _____ Batch no. _____
3. Iodizing agent: potassium iodate /potassium iodide
4. Iodine content: _____ ppm
5. Date of expiration: _____ (12 months from the date of manufacture)
6. Net weight: _____ kg
7. Price: _____ /bags
Caution: Store in a cool and dry place

Table 11.1 - Label for iodized salt packets/bags

Packaging Equipment

Bulk Bag Packing

Bulk bags of 20 - 50 kg capacity can be filled and packed in two ways:

- (i) *Manual*: Manual filling followed by stitching using hand-held bag stitching machine with coil spring suspension unit (approximate cost US \$2,500).
- (ii) *Automatic filling & stitching* (Fig. 11.1): The iodized salt is transferred to a feed hopper through a belt conveyor. Measured quantities of salt from the hopper are pored into a bag, which is then stitched by a stitching machine with a sewing head (approximate cost US \$25,000). The bag moves on a horizontal chain and slat conveyor (2-2.5 m length) which is synchronised with the sewing head and a hand-operated knife and foot-switch control arrangement. The sack is entered into the sewing head, which automatically starts, sews, cuts the stitching thread and stops again ready for the next sack.

The bagged salt is moved into the warehouse. Stacking, positioning and stockpiling the bags can be done either manually or by fork-lift trucks.

Retail Packing

There is a definite trend to pack iodized salt in retail packs of 1/2 or 1 kg polyethylene bags. The filling and sealing of the bags can be done in one of the following ways:

- (i) *Semi-automatic filling and sealing machine* (Fig. 11.2): The packing can be done in a two-stage system consisting of:
 - (a) feed hopper and foot operated filling spout (approximate cost US \$5,000); when the foot-switch is pressed, one fill of preset weight is obtained; the capacity is about 10-15 bags/min or 600 - 750 kg/hour; and
 - (b) a sealing machine with electrically operated foot-switch to seal the filled bags (approximate cost US \$2,000).
- (ii) *Automatic form fill and seal machine* (Fig. 11.3): This machine consists of a volumetric feed unit and a packaging film-forming shoulder and filling tube into which polyethylene film is folded and sealed vertically as a tube. The volumetric feed unit delivers a controlled volume of salt as demanded by the packaging machine. The film is then moved downwards to the length required, and filled with salt, and then the top is sealed. This action also seals the bottom of the following empty bag. The size of the bag can be adjusted during the operation. The filled bags are carried away by a small conveyor to a packing table where they are manually packed into cardboard boxes. The filling accuracy is +1%. The machine capacity is 35-40 bags/min or 2-2.5 tons/hour. The cost of the machine is approx \$20,000.

An important consideration in selecting packaging machinery is the flowability of the material. Product flowability will affect output of bagging, retail pack packaging, and carton filling, etc., regardless irrespective of whether the operation is manual or automatic.

Salt distribution

As described earlier, salt in most countries is produced by many small manufacturers and a few medium or large ones, and is transported by all available modes, including road, rail, sea, and river. The bags must be protected from moisture, dust and heat in transport. The producers or refiners ship salt in bulk bags of 50 or 75 kg or in cartons containing 20-25 packs of 1 kg or 1/2 kg to wholesalers, who in turn distribute the salt to retail outlets.

Guidelines for handling, transportation, and storage of iodized salt

1. Iodized salt shall not be exposed to rain, excessive humidity or direct sunlight at any stage of storage, transportation or sale.
2. Iodized salt shall be transported, stored and kept for sale only in the bag in which the salt was originally packed.
3. Bags of iodized salt shall be stored only in covered rooms or "godowns" that have adequate ventilation.
4. Bags of iodized salt are best stacked on wooden pallets at least four inches above floor level and should not have direct contact with the walls of the storage warehouse.
5. No hooks or sharp instruments shall be used for handling bags of iodized salt.
6. Bags of iodized salt shall be properly stacked and separated from any non-iodized salt, and a stock register with batch numbers and date of receipt and dispatch should be maintained.
7. Bags of iodized salt shall be dispatched, distributed and sold strictly according to the principle of "first in, first out."
8. Agents, distributors and retailers shall cooperate with government-designated officials in the inspection of iodized salt stocks and the drawing of samples, and shall immediately close by stitching all bags opened for withdrawal of samples.
9. Agents, distributors and retailers shall not remove iodized salt from its original bag for the purpose of storage, distribution or sale.
10. The consumers should be advised to store iodized salt in such a manner as to protect it from direct exposure to moisture, heat and sunlight.
12. Bags of iodized salt may be stored in the open only for purposes of retail sale and kept covered or closed immediately thereafter.
13. Retailers shall prominently display the government approval, sign boards and posters relating to iodized salt.

12. INVESTMENT AND OPERATING COST OF SALT IODIZATION PLANTS

The capital investment cost of an iodization plant will depend upon the type, capacity and number of units it will contain, and the consequent size of the building necessary for the plant, utilities, and storage space for raw and iodized salt. It is usually economical to install larger capacity plants at centralized points, preferably at the production site or at an important distribution point. Investment and operating costs are lowest when the plant is located in the storage warehouse at the salt field or mine where infrastructure facilities are already available.

The building itself represents a major portion of the total capital cost, because space must be provided for raw and iodized salt, iodization plant, workshop, office and laboratory. Therefore, to the extent possible, existing salt storage warehouses should be used to house iodization plants. Alternatively, portable iodization plants can be used outside during the dry part of the year, provided the salt is packed immediately after iodization. Table 12.1 summarizes the range of costs for several components of the iodization process. Table 12.2 presents the capital and operating cost for a continuous spray mixing plant, with a capacity of 20,000 tons per year built at a new location. The estimates are based on costs of materials and services in several Asian and African countries. Table 12.3 provides similar estimates for a batch spray mixing plant for 4000 tons per year.

The costs associated with iodization include

- chemicals
- processing
- administration
- additional costs of packaging, and
- plant amortization

Chemical costs depend on the iodine dosage selected. At the current cost of \$8/kg for potassium iodate, every 10 ppm iodine (16 ppm potassium iodate) adds \$0.13 to the price of a ton of salt. Therefore, for the iodine range of 40-100 ppm, the corresponding chemical cost would be in the range \$0.50 - \$1.30 per ton of salt, average \$0.90.

Processing costs include labour, supervision, plant maintenance, spare parts, power, and laboratory chemicals and accessories. Labour and supervision estimates vary considerably depending upon local wage rates, and may typically range from \$2.00 to \$4.50 per ton. Maintenance and spare parts for a standard 5 tons/hour spray mixing plant cost from \$0.20 to \$0.50. Power costs vary from 10 to 20 cents depending on whether the salt is to be crushed prior to iodization or not. Laboratory chemicals and accessories for analysis cost from 5 to 10 cents per ton. Thus the total overall processing cost ranges from \$2.35 to \$5.50, average \$4.00. If HDPE or LDPE lined bags are already in use, there is no increased cost for packaging. Otherwise, the incremental cost of introducing polythene bags is of the order of \$4-\$5 per ton of iodized salt.

Administrative overheads are estimated at 1/3 of labour and supervision charges; they range from \$0.60 - \$1.50, average \$1.00.

Amortization includes depreciation on fixed assets and interest on capital investment. For a plant with all critical components built of stainless steel, its life under normal service conditions can be rated conservatively at 10 years. The life of class I buildings can be 30 years. Provision of the entire capital cost as a grant or subsidy involves no interest expense. Otherwise, interest charges could account for

\$2.00 per ton for an interest bearing loan. Amortization charges will then range from \$0.50 - \$2.50 per ton, average \$1.50. Iodization cost estimates are summarized in Table 12.1.

Thus, the total cost of salt iodization ranges from \$3.95 to \$14.80 per ton, with an average of \$7.40, using existing packaging, or \$11.40 with new packing material. This amounts to 0.4 to 1.2 cents per kg or 1-6 cents per person per year, based on an estimated annual consumption of 3 kg to 5 kg. The retail price of crystalline salt for domestic use ranges from \$0.25 to \$1.00 per kg. From these estimates, iodization increases the retail price of salt by 1 to 24%.

Component	Range (US \$/TON)		Average (US \$/TON)
Chemical (Potassium Iodate)	0.50	1.30	0.90
Processing	2.35	5.50	4.00
Packing material	0.00	4.00	..
Overheads	0.60	1.50	1.00
Amortisation	0.50	2.50	1.50
Total	3.95	14.80	7.40

Table 12.1 - Components of iodization cost

Type of plant :	Continuous spray mixing mobile type		
Capacity :	5 ton/hr (i.e. 20,000 ton/yr, 2 shifts/day 250 working days in a year)		
<u>A. Capital cost:</u>			US \$
1.	Plant comprising feed hopper, spray chamber, screw conveyor, SS drums, air compressor, piping and spares		15,000
2.	Hand trolleys & weighing machine		2,000
3.	Laboratory equipment and chemicals		1,000
4.	Transport, clearing, forwarding, installation, commissioning		5,000
5.	Building 60 m x 20 m = 1200 m ² @ US\$ 300/m ² , brickwalls with AC sheet roofing including fencing, lighting, piping, drainage		360,000
6.	Office and workshop equipment		5,000
<u>Total capital investment</u>			<u>388,000</u>
<u>B. Operating cost:</u>			
1.	Cost of chemical: 50 ppm KIO ₃ , 1,000 kg @ US\$ 8/Kg		8,000
2.	Processing costs:		
	a) Labour and supervision		
	Manager 1 US\$ 500/month	6,000	
	Shift chemist 2 US\$ 300/month	7,200	
	Shift foreman 2 US\$ 300/month	7,200	
	Operator 8 US\$ 150/month	14,400	
	Workers 30 US\$ 100/month	36,000	
	Watch and ward 6 US\$ 150/month	10,800	81,600
	b) Maintenance, spares and lubricants		
	2% on buildings and civil works	3,600	
	5% on plant, equipment and lab accessories	900	4,500
	c) Power for crushing and iodization:		
	10 KW/hr = 40,000 KWH @ US\$ 0.10		4,000
3.	Administrative overheads: 1/3rd of 2(a)		27,200
4.	Depreciation:		
	3% on buildings and civil works	10,800	
	10% on plant and equipment	1,800	12,600
Total cost of iodization of 20,000 ton salt			<u>137,900</u>
Cost of iodization per ton = \$ 6.90			

Table 12.2 - Capital and operating costs for a continuous salt iodization plant

Type of plant : Batch spray mixer
 Capacity : 1 ton/hr (250 kg batch capacity; 4 batches/hour) = 4000 tons/yr assuming
 2 shifts per day and 250 days in a year

A. Capital cost:		US \$
1.	Plant comprising ribbon blender with overhead spray arrangement, SS drum, hand pump, piping and spares	6,000
2.	Hand trolley and weighing machine	1,500
3.	Laboratory equipment and chemicals	750
4.	Transport, installation, commissioning	2,500
5.	Building 20 m x 12 m = 240 m ² @ US\$ 300/m ² . Brick walls with AC sheet roofing	72,000
6.	Office and workshop equipment	2,000
<u>Total capital investment</u>		<u>84,750</u>
B. Operating cost:		
1.	Cost of chemical: 50 ppm KIO ₃ , 200 kg @ US\$ 8Kg	1,600
2.	Processing cost:	
a)	Labour & supervision:	
	Manager cum chemist 1 US\$ 400/month 4,800	
	Foreman 1 US\$ 300/month 3,600	
	Operator 4 US\$ 150/month 7,200	
	Worker 10 US\$ 100/month 12,000	
	Watch and ward 3 US\$ 150/month 5,400	33,000
b)	Maintenance, spares and lubricants:	
	1% on buildings & civil works 720	
	5% on plant, equipment and lab 413	1,133
c)	Power/fuel:	
	Cost of power for crushing and iodization of salt	
	5 KWH/hour = 20,000 KWH @ US\$ 0.10/KWH	2,000
3.	Administrative overheads 1/3rd of 2(a)	750
4.	Depreciation:	
	3% on building and civil works 2,160	
	10% on plant and equipment 825	2,985
Total cost of iodization of 4,000 tons of salt		<u>41,468</u>
Cost of iodization per ton = \$ 10.37		

Table 12.3 - Capital and operating cost for a batch iodization plant

13. SALT SITUATION ANALYSIS

Introduction and purpose

Every country has its own unique pattern of salt production, distribution and consumption. To be successful, a salt iodization program must enter this system with minimum disruption to deliver the required quantity of iodine to the population at large. All countries with a public health IDD problem should first make a situation analysis of salt flows from production and/or importation points through distribution channels to consumption with a salt map. Fig 13.1 shows a sample map for Bangladesh.

A first step in a situation analysis would be to prepare a list of the major producers or importers, production/import/export statistics, and information regarding salt quality, packaging, pack sizes, transport and storage, retail marketing practices, prices and household consumption. These data need to be updated according to the country situation periodically, e.g., every two years. The salt situation analysis will also provide some indication of those aspects of the salt iodization that may need to be monitored.

Salt is produced by solar evaporation of sea water, underground or saline lake brines. It is also extracted from underground natural deposits by dry mining or solution mining (dissolving the salt with fresh water and evaporating the brine). The salt may be sold directly in the crude lump form in which it is produced or refined/dried/powdered before it is packed. Iodization is to be normally integrated at some stage in the salt production/refining system preferably just prior to final packing for retail sale.

Distribution patterns also vary from country to country. The salt passes through a series of levels from the wholesale to retail level before it is sold to the ultimate consumer. Often salt in bulk bags (50 or 75 kg) moves up to a level in the distribution system wherein it is packed in retail packs and then sold. There are several instances where the salt is dispensed in loose form from bulk bags. Fig 13.2 shows a typical distribution system in a country.

Countries are in various stages of planning and implementing salt iodization programmes. Based on their status at the time of planning the situation analysis, salt iodization programs in countries or regions can be characterized as

- non-existent,
- existent but needing substantial modifications,
- existent but needing strengthening, or
- existent and effective

The methodology for a salt situation analysis will depend upon the status of the salt iodization program in the country. The steps to be taken for different situations are summarized in Table 13.1. Annex 1 sets out the information required to make a salt situation analysis.

Status of Salt iodization programme	Recommended action
A. Non-existent	Analysis should include a survey of the extent and severity of the problem region-wise, analysis of salt production and distribution patterns, and identification of the best point for iodization. Based on these data an implementation program can be drawn up.
B. Existent but needing substantial modification	The salt production, distribution and consumption patterns should be reviewed to identify the bottlenecks that hamper successful implementation of control programs. The modification of the program may involve more effective support measures such as quality control, publicity, incentives, legislation and enforcement.
C. Existent but needing strengthening	The programme should be periodically reviewed to ensure that its tempo is maintained. In order to eliminate iodine deficiency permanently, iodization of salt and its distribution should become an integral part of a salt production and distribution system that will run on its own momentum after an initial period of support and monitoring.
D. Existent and effective	Periodic monitoring of iodine levels at the production and consumption level

Table 13.1 - Recommended action for different salt iodization situations

14. STRATEGY FOR DEVELOPING A SALT IODIZATION PROGRAM

The preceding chapters have described the technique of salt iodization. Next we consider the translation of this technology into an effective program of iodine prophylaxis. A review of the salt production and distribution systems in various developing countries shows common patterns and constraints in implementing salt iodization programs. These similarities lead to a few general guidelines for strengthening the programs and overcoming the constraints, as described below:

1. Assessment of prevailing conditions

A salt situation analysis should be conducted to determine the status of the programme and identification of bottlenecks or major areas that need strengthening. The procedures for such an assessment have been outlined in the previous chapter.

According to a UNICEF estimate, the approximately 90 developing countries which have an iodine deficiency public health problem can be classified into three groups depending on their main source of salt and the ease with which salt can be fortified:

- i) Thirty five countries, many of them small and landlocked, where there is virtually no domestic salt production and almost all salt used is imported. In these countries the ideal strategy will be for salt to be properly iodized in the country of origin. Compared to costs of packaging and transportation, the additional costs of iodization should be low. These costs might be absorbed by consumers or through more efficient and competitive purchasing. Programme costs will therefore be mainly for advocacy and monitoring.
- ii) Twenty six countries where most salt is processed and packed in a small number of large modern refineries or where extensive salt iodization is already under way. In these countries the main programme costs will be for advocacy and monitoring and perhaps loans for purchase of equipment. Many of these countries are salt exporters, and ensuring that all salt exported is iodized will help reduce IDD in the importing countries.
- iii) Thirty countries where most salt is produced by large numbers (hundreds or even thousands) of traditional or artisanal producers on a small scale. Universal salt iodization will be most expensive and most difficult to achieve in these countries. Small producers will need to be supported and encouraged to sell their salt through 'cooperative' refineries or iodization plants that can be well managed and easier to monitor.

2. Organization of salt production, iodization, and distribution

In most countries, the salt producing units are concentrated around a few areas, often far removed from the iodine deficient regions. Salt moves from production to consumption centres by different modes of transport. Distribution patterns are complex and erratic, making it difficult to regulate a dual market of iodized and non-iodized salt or to achieve a targeted program of delivering iodized salt only to the endemic areas. The only long term solution in most cases is universal (i.e., country-wide) iodization of all salt for human and animal consumption.

To be effective, a salt iodization program should involve all salt producers. In countries that already have a modern salt industry that provides most of the salt, iodization is likely to be simple, straightforward, acceptable, and will involve only marginal cost increases. In many countries, refined, packaged salt is already becoming popular for a variety of reasons. This trend should be encouraged

and accelerated. In countries where salt is still produced by numerous artisanal producers, iodization with the necessary quality control and supervision will be much more difficult. It will be more effective to advocate for and support modernization of the salt industry so that a relatively small number of large producers or refiners compete to produce good quality packaged salt rather than to provide iodization facilities to hundreds of small producers. Small salt producers can be encouraged to participate in cooperatives with a central refinery iodizing, packaging and distributing their salt. Where this is not feasible, at least the iodization and marketing of the iodized salt can be done on a cooperative basis. Small producers should be registered and required periodically to report to the appropriate local government authority, the size and location of their production site, and the quantities of salt produced and dispatched, for monitoring the distribution system.

An effective iodization programme will require good quality control and packing to ensure that the iodine is retained in the salt until it reaches the consumer. Expert assistance should be made available to plan for and help upgrade the salt production and processing technology to facilitate iodization. In important salt producing areas, the governments should establish model salt farms where farmers can learn correct salt production procedures in short courses from qualified instructors. The model farm personnel can also prepare simple manuals in the local languages on production practices, quality control and iodization techniques. The main objective of the model salt farms is to improve the quality of salt produced by the small farmers to make it more suitable for iodization. The model farms can also develop simple batch iodization plants appropriate for local conditions and can instruct the farmers in operation and maintenance of these plants.

Salt producers or refiners will need to be trained in correct application techniques, procure and store quantities of the correct grade of potassium iodate and will need to maintain records and be accessible to government inspectors.

3. Location of iodization plants

As part of the overall strategy of a prophylactic program, attention must be given to the movement of salt from its production or importation point to the consumer. The aim is to identify convenient points where iodization can be introduced into the prevailing system at minimal additional cost. For salt producing countries, the best iodization point is after production or refining and before packing. For salt importing and refining countries the best point is after refining and prior to packing. For salt importing countries where there is a single entry point and a single large importer, the convenient point is the entry site, where the salt is invariably repacked. For other importing countries where there is one source and multiple importers, it is best to specify that the salt be iodized at source at the prescribed level.

Sometimes a combination of strategies must be adopted. There are both advantages and disadvantages to locating the iodization plants either at the point of manufacture or close to the consuming areas. Iodization at the production site entails minimal additional handling but risks losses in transit and storage. If salt is iodized near the consumption points, losses may be lessened but multiple handling and storage may make it uneconomical. The problem also arises as to which agency would own and operate these plants at the consumption centres and bear the additional handling charges. In general, the consensus is in favour of locating the plant at the production site or at the refining point just prior to packing the salt. Under proper iodization and packing conditions, salt has been found to retain at least 75% of its iodine after 9 months of storage. Once iodization at source is accomplished at the prescribed level and the salt is packed properly, the chances of iodine reaching the consumer in the prescribed amounts are good.

4. Economic and Marketing Incentives

An immediate question concerning iodization is whether it will add to the price of salt, and if so, how much. Is this price to be subsidized by the government, absorbed by the producer/importer or passed on to the consumer? The answer for a particular country requires analysis of the stages that involve additional cost, including salt refining, iodization, and packing.

Chapter 12 has estimated that a ton of iodized salt costs \$0.50-\$1.30 for the iodine addition alone, \$2.35-5.50 for processing, and \$4.00-5.00 for packing material. Thus, exclusive of packing material cost, iodization could add between \$3.95-14.80 per ton salt or 0.40-1.20 cents per kg of salt. Often costs are already being incurred at some of these stages and it may be simply a matter of adding iodine at the appropriate point. It must be understood here that salt refining (i.e. converting coarse sea or rock salt into high purity free flowing salt) is an expensive process independent of iodization, and it also involves expensive packing material. Salt refining, while desirable, is not included in the present calculations.

It will always take a few years to achieve universal iodization in a prophylactic program. Until this goal is reached, program planners face several difficulties. Price differentials tend to drive out higher priced iodized salt in favour of cheaper non-iodized salt. Nutrition education to gain consumer preferences for iodized salt is often slow to work. The problem is compounded by the fact that the consumers most at risk usually live in conditions of greatest poverty in the remotest areas where the price of salt is the highest and the price differential the largest. These people are often uneducated and hardest to reach with educational messages.

The availability of cheaper non-iodized salt is probably the most persistent problem for prophylactic programs in developing countries, and it demands effective and durable solutions. It calls for directly or indirectly subsidizing the iodization cost at the production end to push iodized salt into the market at a price no greater than that of the non-iodized form. It is, therefore, recommended that producers of iodized salt be offered incentives to ensure price equity. Typical incentives are interest-free loans for purchase of iodization equipment, a free supply of potassium iodate, a subsidy for processing, subsidization of salt transportation to remote areas, and exemption of the iodate and iodization equipment from all taxes or import duties. Once the target of universal iodization is achieved and only iodized salt is available in the market, the subsidies can be gradually withdrawn and the extra cost of iodization fully passed on to the consumer

Packaging material often accounts for a sizeable difference in salt prices. The use of plastic packaging for all grades of salt could be made compulsory by law and the extra cost passed on to the consumer.

5. Program implementation

National personnel, aided as necessary by technical assistance from international agencies and experts, should design specific actions to increase the coverage and effectiveness of the salt iodization programs in their countries, specifically in the following areas:

- A. Undertake a detailed salt situation analysis and draw up a plan for integration of iodization in the salt production system that will ensure that all salt for human and animal consumption is adequately iodized.

- B. Develop a communications strategy that will focus on increased recognition for IDD in general and goitre in particular as disorders of serious magnitude, increasing awareness of preventability through iodized salt and emphasizing the product attributes of iodized salt.
- C. Conduct an initial review of existing legislation and legal frameworks (for example food standards, public health acts and food adulteration acts) to establish the most appropriate regulatory framework for compulsory salt iodization. Based on this, an order, standard or regulation requiring all salt for human and animal consumption to be iodized will need to be issued. This can be supported later with a law.
- D. Prepare a detailed plan for universal salt iodization and the facilities and actions required to achieve it. Key issues will include:
- the kind of reorganization of producers and distributors that will be required
 - the number and types of iodization plants and accessories that are required; the costs and sources of supply
 - the energy sources for the plants and the needs for standby power generation
 - the procurement and distribution procedure for potassium iodate
 - the sources of funding for iodization plants, potassium iodate, packaging material and other operating costs.
- E. Establish a procurement and installation plan for the iodization equipment and the training necessary for its operation and maintenance.
- F. Establish quality control procedures, the number of random visits by inspectors to salt producing units, and the number of internal quality control checks required. Establish a procedure for checking salt quality at retail and household levels. Specify action to be taken in the event of non-compliance with regulations.
- G. Promote public education, political support and appropriate commercial means to improve the distribution and consumption of iodized salt and to ensure that the supply is regular and uninterrupted.
- H. Enact laws requiring all salt to be iodized. Provide continuing support for producers for a period sufficiently long to enable them to comply with the law.

15. SALT INDUSTRY PARTICIPATION IN IDD CONTROL

Over the past decade there has been a world wide movement by consumer groups to raise industry's participation in tackling social and environmental problems. Industry is responding to this call by including these considerations in its corporate philosophy. Viewed from this angle, IDD control presents an opportunity for the salt industry to derive economic benefits for itself while simultaneously providing a social benefit to the community by fortifying the salt it produces and sells.

Salt iodization programmes are an example of an industry that had previously worked in a largely commercial environment now being required to play a leading role in health intervention. In order to have an effective and sustained salt iodization programme, it is vital for the Health Ministry and the salt industry to work in close collaboration, each explicitly understanding and recognizing the other's view points, concerns and interests.

The salt industry should cooperate with governments to design concrete actions to increase the coverage and effectiveness of salt iodization programs in the less developed countries. Specific areas where the salt industry can assist in IDD elimination are:

- **Awareness creation:** The salt industry can increase awareness among its own members, trade partners and associates regarding the problem of iodine deficiency and the key role they play in its elimination. This awareness can help create a climate of support for both official development aid and private donor assistance. Salt industry associations should consider an information program that emphasises the established role of iodized salt in combating IDD in industrialized countries, the continued existence of IDD in the developing countries, and the need for action and funds to eliminate IDD. Such information can be in the form of newsletters, flyers, information panels on salt packets and could greatly support fund raising campaigns being organized by voluntary organizations such as Kiwanis.
- **Salt iodization:** More and more countries that import salt will request that it be iodized. When a country with a known IDD problem requests a major producer for food grade salt that is not iodized, the producer should alert the purchaser regarding the importance of iodized salt and the ability of the supplier to provide quality iodized salt at the same price if possible. This information might reinforce the message that will be delivered within the country to the salt industry by the Ministry of Health.
- **Identification of iodized salt:** It would greatly boost international trade in iodized salt if the industry adopts a logo indicating that the salt meets basic international quality standards for iodized salt. The logo with a red-line through it might be used to indicate that the salt was not iodized.
- **Technical support:** Salt industry members from industrialized countries could provide experts for short missions to countries that have specific needs in their salt production, refining, iodization and quality control programs. Technical support could also be provided for small training programs. Where feasible and necessary, members could arrange visits to their plants by technicians from developing countries.
- **Development support:** The salt industry could support the development and testing of new appropriate technologies (e.g. innovations in salt processing and handling machinery, manufacturing, refining and handling procedures, economic and financial analyses, innovative and cost-effective packaging, communications and marketing, advertising, labelling and quality control). The industry could assist in the development of technologies for multiple fortification of salt with other nutrients. Several countries are interested at least in double fortification with iodine and iron.

- ***Standards and guidelines:*** The salt industry could assist in the development of quality standards for iodized salt and guidelines for packaging, transport and storage.
- ***Information dissemination:*** At the regional and global level, salt industry associations could serve as clearing houses for dissemination and exchange of technical and scientific information relating to salt production and iodization. They could include more on IDD and salt iodization in their newsletters.
- ***International network:*** The Industry could consider developing an international network that will bring together the large producers from the industrialized countries and the medium and large producers in IDD-affected countries for exchange of information and experience.

The goal of universal iodization of all human and animal salt in all countries with IDD problems in the world is a lofty target. While considerable progress has been made in initiating and streamlining control programs through salt iodization in several countries, logistic problems, bottlenecks and resource constraints persist. The salt industry in the developed countries can play an important role at the global, regional and country levels in terms of advocacy for fund-raising and technical support

16. CHARACTERISTICS OF EFFECTIVE SALT IODIZATION PROGRAMMES

While salt iodisation is technically a straightforward process, its sustained large scale implementation calls for changes within political, administrative, technical and socio-cultural spheres. Some countries have been moderately successful in this process, but others have been struggling for many years to establish effective programs. Available country experiences indicate certain key issues have a bearing on the success of national programs:

1. Policy support: Several health and nutrition programs compete for priority action by policy makers. Raising high level awareness of the problem and the effectiveness of its control within a short period through salt iodization has been an important factor in generating political will to support serious control and monitoring efforts. Awareness has been created by assessing and making available epidemiological information regarding IDD prevalence and the meaning of the data to high level politicians and bureaucrats. Initial promotion of the program by convening a National Advocacy meeting and/or issue of a statement by the Head of State has been extremely effective in several countries, e.g., the Philippines and China. Resolutions by regional groups like South Asia Association for Regional Cooperation (SAARC), Association of South East Asian Nations (ASEAN) and the Organization for African Unity (OAU) calling for universal salt iodisation are also effective in initiating action.

2. Involvement of multiple sectors in the planning and administration of salt iodization programs: While the responsibility for initiating, coordinating and monitoring an IDD control programme rests primarily with the health sector, its planning and implementation calls for active involvement of other sectors like industry, trade, planning, transport, legislators, communicators and educators, to implement and integrate iodization into the salt production and distribution system. In countries like India, Sri Lanka, Bangladesh and Nepal, the industry sector is assigned the role of planning and implementing the iodization programme, with the health sector providing financial and impact monitoring support.

3. Strong advocacy with the salt manufacturing and trading community: Since the salt sector is a key player in the project, its motivation and involvement are an essential prerequisite. In several countries, the salt industry needs technical, marketing and financial support. For example, the commitment in Cameroon of one refiner, who processes almost the entire requirements of that country and that of three or four neighbouring countries as well, has led to effective iodization of all salt in that region. Strong support for iodization is a hallmark of Bolivia's small salt manufacturers. Organized into cooperatives, they have ongoing technical support and educational workshops that foster commitment to the overarching goal of IDD elimination. Similarly, Ecuador has placed emphasis on establishing good relationships with producers, explaining the goals of fortification, and instituting annual information and motivation meetings. The Bangladesh Small Industries Corporation, which oversees salt iodization in that country, is in constant touch with salt crushers to understand their problems and needs. In India, workshops are held specifically for salt producers and traders to understand their problems. The Salt Commissioner in the Ministry of Industry has several full-time officers exclusively dealing with the iodization program. In China, a major UNDP/UNICEF-assisted project has recently been launched to upgrade the salt industry to facilitate effective iodization.

4. Well conceived information, education and communication campaigns incorporating a social marketing approach to educate consumers and generate demand for iodized salt: In both Ecuador and Bolivia, rural consumers in particular had to be convinced of the importance of iodine to their health, since they had to spend scarce resources to pay the increased cost of iodized salt. A long-standing cultural acceptance of goitre as normal in Bolivia and the absence of knowledge concerning the less obvious manifestations of IDD had to be addressed in educational strategies. Using a social

marketing approach enhances the IEC component focusing messages on the perceptions and attitudes of consumers. In each case, the content of the educational messages is restricted to a few basic ideas. The actual communication of these messages occurs through a variety of media including radio, television, traditional drama forms and one-on-one counselling. The use of multiplier educators, teachers, village health volunteers, local political leaders, trained by IDD control program staff, proved to be highly effective in Bolivia and Ecuador. IEC campaigns have greatly assisted programs in Tanzania and Bangladesh, among others.

5. Economic and marketing incentives: In most countries potassium iodate is provided free of cost to producers for at least the initial 3-5 years. Thereafter the subsidy is phased out. In addition, Brazil has donated iodization equipment and provides technical assistance in production and quality control to producers. Bolivia guarantees sale of iodized salt once it is produced. India offers priority allotment of rail wagons for iodized salt movement and promotes marketing by progressively banning the entry of uniodized salt into the endemic States. Bhutan and Ethiopia provide even the packing material free of charge. Compared with most consumer products, salt fortification subsidies are small but play a crucial role during initial promotion. Their withdrawal must be in a phased manner. In some countries like Indonesia and India, sudden withdrawal of the iodate subsidy had an adverse effect on progress.

6. Monitoring of iodine levels in salt: Frequent testing of iodine levels at iodization plants and periodically at intermediate points in the distribution network, retail outlets and the household level has been characteristic of countries with successful programs. Ecuador and Brazil sampled salt on a weekly basis at production plants during the early phases of the fortification program in order to detect variability in iodine levels quickly and take corrective action. Bhutan has developed a systematic monitoring and reporting system for iodine at the levels of production, distribution, and consumption. The reports are reviewed centrally every month and corrective initiated when required. Another useful exercise is the involvement of other sectors like NGOs, voluntary organizations, and schools in monitoring the salt, using the low cost field test kits. This helps increase awareness and community participation.

7. Legislation and enforcement: By appropriate legislation, Bolivia and Brazil have fairly successfully precluded the use of cheaper, unfortified animal salt by rural populations while at the same time providing the benefits of iodine to livestock in iodine deficient regions. Enforcement of the regulation has proved critical to ensuring the quality of iodized salt, especially in countries such as Bolivia, where there are multiple small producers. Uniodized salt, when identified by inspectors, is confiscated or destroyed. In Ecuador, legal sanctions in the form of fines and newspaper publication of non-compliant brand names are used to enforce quality control. For many years in Kenya, non-iodized salt was allowed in the market as long as it was labelled as 'lacking a necessary nutrient.' This legal loophole was closed in 1988.

8. External donor financial and technical assistance: This has been critical to the success of initial and, occasionally, to ongoing efforts for salt iodization in many countries. In almost all developing countries, international financing has been responsible for the establishment of IDD control programs that implemented salt iodization. External technical consultations and international training of national technical staff involved in all phases of the fortification contributed to the development of iodization activities. External financial support for import of iodization equipment, quality control accessories and iodine for an initial period has also been important. International agencies have also played a key coordinating role among the different sectors.

9. Programme monitoring: Systems should be functional from the onset of the iodisation program with rapid analysis and dissemination of data to inform managers of decisions regarding mid-program changes and corrective actions at production sites. Ecuador and Bhutan analyze their cumulative salt sampling data at regular intervals and communicate results to involved industry representatives and health personnel.

10. Programme leadership: In Bolivia and Ecuador, the role that individual leadership played in the progress of salt fortification programmes deserves note. Perseverance during early years of governmental inaction and the willingness to participate at the local level of programme activities has characterized the administration of both country programmes

11. Regional cooperation: An innovative regional strategy has been initiated for countries in Sub-Saharan Africa to ensure that all salt produced for human and animal consumption is iodised at source. Salt producing and importing countries from 9 Southern and Central African countries met in April 1992 to develop a regional strategy to ensure that all salt produced for human and animal consumption is iodised at a uniform concentration. Similar meetings were held for the West and Central African countries in October 92 and for Central America in October 1993.

17. IODIZED SALT FOR ANIMAL CONSUMPTION

It is now well appreciated that the iodine deficiency disorders (IDD) are a major public health problem in the world affecting large populations in over 110 countries with nearly 1.6 billion people at risk. What is not well known is the severe effect of iodine deficiency on animals. Farm animals share with humans the risk of iodine deficiency at all stages of growth and development, from conception to physical performance.

Reproductive failure is often the outstanding manifestation of iodine deficiency and consequent impairment of thyroid activity in farm animals. The birth of weak, dead, or hairless young in breeding stock has long been recognised in goitrous areas. Foetal development may be arrested at any stage, leading to either early death and resorption, abortion and stillbirth, or the live birth of weak young.

In the developed countries, iodine supplementation has greatly reduced the incidence of IDD for both humans and animals. For example, reports indicate that before iodine feeding was practised in Montana, USA, its deficiency caused an annual loss of hundreds of thousands of pigs. Records from other areas show serious losses in the sheep and cattle industries from lack of iodine.

Salt is the predominant vehicle for providing supplemental iodine for farm animals. Iodine may be incorporated into the salt, mineral mixture or concentrate feeds. For grazing animals in some inaccessible parts of the world iodized salt blocks are air dropped. Salt iodized with both iodide and iodate are equally available to livestock. EDDI (ethylene diamine-dihydro-iodide) is an organic iodide used at relatively high dosages for treatment of foot rot, lumpy jaw and other conditions.

Iodine levels in salt for animals

In the developed countries there is a range of trace mineralized salt preparations that caters to each variety of livestock and poultry. In these trace mineralized salts, typical levels for livestock are 70-80 ppm iodine. In the developing countries, organized livestock rearing is a growing industry but still limited. The farmer usually buys one type of salt from the market for his livestock as well as for his family.

Estimates of iodine levels in salt are presented for different animals in Table 17.1, showing a wide range from 30-400 ppm. As an approximation, if the level of iodine in the salt is at least 20 ppm at the consumer level, this will ensure minimum requirements for many domestic animals. However, if special categories like cattle and sheep continue to demonstrate consequences of iodine deficiency, then additional iodine supplementation may be required through cattle feeds or other sources. There is no apparent risk of toxicity for any class of animals even if salt containing levels of iodine of more than 200 ppm is fed to any class of animals.

Class of animal	Iodine requirement in total diet (ppm)	Salt Consumption (kg/year)	Iodine content required in salt (ppm)
Swine	0.14	4.1	28
Beef cattle	0.2 - 2.0	10	40 - 400
Dairy cattle	0.25 - 0.5	24.3	50 - 100
Horses	0.1	10.9	20
Sheep	0.1 - 0.8	4.1	20 - 160
Goats	0.15 - 0.8	4 - 8	30 - 240
Poultry	0.3 - 0.4	0.2	120 - 160

Table 17.1 - Iodine requirements for animals

Implications for the universal salt iodization programme

There is now a global thrust to eliminate iodine deficiency in humans through the universal iodization of salt. A mid-decade goal of universal iodization of salt has been set for the end of 1995. Iodization programmes are already under way in over 60 countries. In order to have effective salt iodization programs, all salt required for human and animal consumption should be iodized. If only the salt for human consumption is iodized, the non-iodized salt, which is cheaper than iodized salt, is also available in the market for animal consumption. This leads many people to purchase the cheaper non-iodized salt for their use as well. The availability of two types of salt also poses a major problem to the law enforcing agencies, for they can not take legal action against those selling non-iodized salt since it is being used for animal consumption.

Legislation covering the iodization of salt for human use should be extended to include all salt for livestock consumption as well. This will have the double benefit of ensuring that animals receive iodine supplementation and also ensuring that only one variety of salt - iodized salt - exists in the market. Advocacy and publicity campaigns should stress the need for iodine in animals and highlight the benefits of their receiving it.

In many countries, it is very difficult to have separate grades of iodized salt for animals. Therefore a separate monitoring of iodine intake of animals will be necessary to determine if certain species will require additional supplementation through feeds etc.

18. SOCIAL ADVOCACY AND DEMAND CREATION

Even with a target of universal iodization of all edible salt in a country and given the most efficient distribution, monitoring and enforcement systems, supported by legislation, the implementation of the programme will take place only over a period of time. Many countries have multiple sources of salt, hundreds of scattered small producers and varying distribution patterns. Further, strict enforcement of laws and quality control is a major problem in some developing countries. During the crucial interim phase when both iodized salt, a high priced new product, and uniodized salt, a low priced established product, are available in the market, education and communication at all levels must add to the power of the supply push by creating a demand pull for iodized salt. Educated and motivated consumers who insist on iodized salt become a force that salt retailers and manufacturers cannot ignore and to whom they must respond by ensuring a steady uninterrupted flow of iodized salt. On the other hand, unaware consumers will resist change and can become a major obstacle to the programme by encouraging the circulation of unfounded rumours against iodized salt.

Some people believe that it is possible to do good by stealth. Their argument goes as follows: if health intervention can simply be imposed on people, why not just add iodine to all available salt? Everyone is bound to consume it and IDD will disappear soon enough. No one except health professionals need ever know about IDD or how it needs to be tackled, and the expense and effort of a consumer information programme will have been saved.

However, the experience of several countries shows that programmes have often faltered or failed due to lack of awareness at all levels and to inadequate coordination among implementing agencies. This lack of awareness exists not only among those afflicted by IDD, but also among medical professionals and health workers and, more importantly, among legislators and key-decision makers who frame health policies and programmes and oversee budget allocation for various activities competing for the same limited resources. This situation underscores the crucial role of the communication component of an IDD control programme to gain the understanding and support of these key actors. Therefore, this component must be built into the programme from the outset. The communications component should consist of:

- (i) presentations to the highest policy-making bodies, to ensure continued national commitment and budgetary support;
- (ii) communication with public health professionals, government officials at every level and the salt trade, to obtain their understanding and support;
- (iii) communication research among the communities to gauge their knowledge, attitudes and practices (KAP) with regard to IDD problems, solutions and the use of iodized salt;
- (iv) communication research among iodized salt manufacturers and traders to understand KAP with respect to IDD, iodized salt, economics and logistics of salt trade; and
- (v) dissemination of effective messages through appropriate channels to the target communities in order to educate and motivate them to accept the new product and to change their behavioral patterns (with regard to purchase, storage, use and consumption of salt) in order to achieve the programme's objectives.

The communication strategy flows from the programme strategy and is determined by whether the IDD control programme is based on

- i) iodizing all the salt in the country
- ii) targeting iodized salt to the endemic areas
- iii) providing iodised oil exclusively to endemic areas, or
- iv) using both oil and salt in a phased manner.

It is also dependent on the reach of existing mass media and on the availability of other channels of communication at the community level. The awareness and practices of people with regard to goitre, cretinism, and salt consumption need special attention. Communications planning must go hand in hand with programme planning. Table 18.1 sets out the different target audiences and possible media or materials to reach them.

Today, the term "social marketing" is used increasingly in the health field. Basically, it refers to the application of commercial marketing techniques to achieve a social objective. Communicators in the health and social field have witnessed the enormous success of demand creation techniques in the selling of consumer products, even those products that are incompatible with individual or community needs. And although the primary objectives of consumer marketing and social marketing sometimes differ very significantly, their techniques are becoming increasingly similar. The social marketing of IDD control must become a collective effort involving health and medical professionals along with specialists in marketing management and communication.

Target Audience	Communications Objective	Possible media
Policy Makers	Insure support for IDD control programme and budgetary commitment	Films, audiovisuals, expert presentations, national seminars
Opinion leaders (village elders, religious heads, party workers, school teachers, health workers)	Motivate them to become more involved in persuading others to accept the programme	Films, audio-visuals, person-to-person communication, radio or TV interviews, press reports, direct mail leaflets, etc
Programme planners/ implementers, medical professionals, salt trade	Seek their understanding, support, and involvement to impart skills	Workshops, seminars, professional journals, training courses, manuals, etc.
Consumers (the public)	Create a demand for iodized salt and make the acceptance long term.	Mass media (news-papers, radio, TV, cinema), traditional folk media, person-to-person communication, schools, places of worship, political parties.

Table 18.1 - Target audiences and possible media and material to reach them

19. LEGISLATION

For most developing countries, an effective salt iodization program needs to be supported by effective legislation. The law should specifically address the following requirements:

- 1) Mandatory salt iodization at a level to be determined by the public health authorities of each country
- 2) Applicability of the measure to all salt that is produced, imported or marketed in the country for human and animal consumption.
- 3) The law can specify the type, quality, and amount of iodine compound to be added, the levels of production/port of import, distribution and consumption or can leave these details to enabling regulations by a designated government unit, frequently the Ministry of Health; the latter approach offers the flexibility of responding promptly to changes in salt consumption or other factors without passing new legislation.
- 4) Control of labelling and advertising.
- 5) Quality control and monitoring, with designated responsibility and regular mandatory reporting of results.
- 6) Enforcement and penalties for non-compliance.

The situation varies very much from country to country. Incorporation of iodized salt in such legislation does not present a problem when food legislation already exists but is more difficult without it, since a regulation on iodized salt must depend on some existing law. It is better, in fact, for salt iodization to be a part of an existing regulation e.g. one relating to food quality, than to be a separate law or Act of Parliament, because the latter is more difficult to get adopted and also, to get amended, if that becomes necessary.

The main principles concerning a regulation for salt iodisation are:

- 1) A Preamble states succinctly the Law on which the Regulation depends, e.g. a Food and Drugs Act, or a Public Health Act. Such acts usually empower a ministry to develop regulations for its implementation. It is through the regulations that the government lays down the specific requirements that the food industry and others must follow in order to comply with legal requirements. The clauses relating to this process should be cited, and also any clauses relating to the provision of food of adequate quality for human health. The Preamble should also state the purpose of the regulation: why iodization of salt is necessary - to prevent IDD which are endemic in the country and have public health and socio-economic consequences.
- 2) The Operative clauses normally provide for:
 - Applicability of the regulations: All salt for human and animal consumption in the country must be iodized in accordance with specifications given in an Appendix. Any exemptions should be specified.
 - Health (or other) personnel authorised to administer the regulations and the Act.
 - Penalties to be inflicted on persons responsible for infringement of the Regulations -probably the penalties will be specified in other regulations (which may be cited elsewhere). The penalties may be in the form of a fine, and/or confiscation of licence to import. A first offender should be given a second chance but on two offences, licence should be withdrawn. However, penalties

- should not be so great as to constitute an impediment to importation of salt; that would arouse the antagonism of those whose cooperation is essential.
- Licensing requirements for those importing, manufacturing, distributing, selling or exporting the product.
 - Quality assurance and record-keeping requirements at production and distribution levels.
 - Packaging and labelling requirements
 - Transport, storage and display requirements
 - Inspection and investigation procedures, including collection and examination of salt samples on the spot for iodine content, and/or submission to a central laboratory for analysis
 - Enforcement procedures
- 3) An Appendix states the required characteristics of salt. These should include physical characteristics, constituent levels, iodine content, packaging and labelling requirements. These important characteristics have a bearing on the retention of iodine - if the required specifications are not met, too much of the iodine is liable to be lost.

For detailed notes on legislation and regulation including model formats, readers are referred to "Food Fortification - legislation and regulation manual" by Rose Nathan. (draft), Programme Against Micronutrient Malnutrition, Emory University of Public Health, Atlanta, Georgia, USA (1994).

Typical problems which may arise include the following:

- 1) Existing or new legislation may be circumvented by some people bringing in non-iodized salt, said to be for animal consumption. In practice this is coarse salt that may be indistinguishable from salt for human consumption. Therefore it may be better to have legislation or regulations that cover salt for both human and animal consumption. But the legal basis for regulations concerning salt for animal consumption may not exist.
- 2) In the absence of a definitive law on which to base the regulation, another solution, even on a temporary basis, is by Administrative Instruction. This may be useful for example from the Ministry of Commerce or Ministry of Finance (in charge of Customs), prohibiting the importation of salt which is not iodized in accordance with instructions of the Ministry of Health.
- 3) Lack of awareness of the legislation on the part of salt traders, or of the importance of adequate iodization for the health of the people, may lead to unintended or deliberate non-compliance with the legislation. It is very important therefore that information-education-communication reach specifically all those involved in salt production or trade at all levels, as well as the general public.

Finally, it must be said that the private sector is often capable of taking appropriate action, even in the absence of legislation or regulation. For instance, private companies in several countries have taken action to iodize their salt even before the formulation or finalization of legislation. But in the end, some sort of legislation is bound to be necessary - partly in case of dispute by any antagonistic group and partly to ensure that the iodization becomes a permanent arrangement, not dependent simply on voluntary cooperation.

20. PROGRAMME ADMINISTRATION AND COORDINATION

While the responsibility for initiating, coordinating and monitoring the programme lies primarily with the Ministry of Health, IDD control is a multi-sectoral activity and requires the motivation and active involvement of the following Agencies for specific functions:

Function	Agency/Department
Planning	Ministries of Planning/Health/Industry/ Information & Publicity
Administration & Coordination	Ministry of Health
Salt Iodization, Packing & Distribution	Salt Manufacturers/traders, Ministry of Industry
Quality Control	Medical Research Institute, Ministry of Health, Food Standards Institute
Information, Education & Communication	Ministry of Information & Publicity, Health Education Bureau, Ministry of Health
Legislation	Ministry of Law, Ministry of Health
Monitoring & Evaluation	Medical Research Institute, Ministry of Health
Technical & Financial Support	Ministry of Finance, Multilateral and Bilateral Agencies

National Workshop

As a first step, it is useful to convene a National Workshop to bring together policy planners, scientific experts in the field, the salt industry, officials of all concerned Ministries like Health, Education, Industries, Law, Information & Publicity, Trade, the National Standards Institute, and representatives from the State or Provincial Departments of Health. The Workshop should have the necessary political participation and backing at the highest level to gain Government acceptance, financial and administrative support. The Workshop should review the IDD situation in the country based on available data and formulate a plan of action for initiating control measures.

Project Document

At the planning stage, it is necessary to formulate a comprehensive project document outlining all components of the programme, timetable for implementation, requirements of equipment and accessories, manpower, training and financial requirements.

National IDD Control Committee

The first step would be the constitution of a National IDD Control Committee with representatives from the above sectors. The terms of reference of the Committee should be to review periodically:

1. Baseline and follow up assessments of IDD
2. Salt situation analysis and strategy for production and distribution of iodized salt
3. Implementation of the salt iodization programme, supervision and monitoring
4. Development and implementation of iodized oil intervention in severely IDD affected areas
5. Development of IEC material to promote the programme at all levels
6. Establishment of laboratory facilities and other infrastructure necessary for the surveillance of the programme
7. Training of health professionals, salt industry and health educators
8. Periodic evaluation of the programme and updating strategy according to changing circumstances and effectiveness
9. Documentation and dissemination of programme performance

The Committee should meet regularly (quarterly or half-yearly) to review all components of the Control Programme and recommend appropriate action. The Programme should have a full-time manager who will also function as ex-officio Secretary of the National Committee and initiate and coordinate follow up action on all its recommendations. The summary checklist for implementing an IDD control programme is given in Table 20.1.

Table 20.1 - Summary Checklist for IDD Control Programmes

Objective	Activity	Responsibility
1) Make initial assessment of	1.1) Compile reports of past IDD surveys 1.2) Conduct rapid assessment "spot" goitre survey. 1.3) Prepare situational analysis	1) IDD Programme Officer to be assigned by the Ministry of Health
2) Communicate findings of situational analysis IDD extent & severity	2.1) Inform Planning Commission and Ministry of Health 2.2) Alert relevant government agencies, NGOs, private sector and request their participation.	2.1) IDD Programme Officer 2.2) Planning Commission and Ministry of Health
3) Create Plans of Action	3.1) Create infrastructure i) National Council for the Control of IDD (NCCIDD) ii) Inter-sectoral salt iodization Commission iii) National IDD Control Unit iv) Communications units within (i) and (ii) iv) IDD Monitoring Laboratory 3.2) Create Plans for IDD Control Programmes: i) National IDD Survey ii) Emergency Programme for severely endemic areas iii) Permanent Programme for all endemic areas.	3.1) Planning Commission, Ministry of Health, Ministry of Industry/Mining (Salt) 3.2) i) IDD Control Unit ii) IDD Control Unit iii) Inter-sectoral Salt Iodization Commission
4) Achieve political support and mandate to prevent IDD	4) Establish and provide budget for IDD Control infrastructure and programmes.	4) Planning Commission

Objective	Activity	Responsibility
5) Implement IDD Control Programmes	5.1) Emergency Programme (iodised oil) 5.2) Permanent Programme (Salt iodization) 5.3) National IDD Surveillance	5.1) IDD Control Unit 5.2) Inter-sectoral Salt Iodization Commission 5.3) IDD Control Unit
6) Assess Programme Development 6.1) Continuous assessment 6.2) Periodic re-assessment of situation	6.1) Permanent monitoring of IDD Control Programme Progress i) Emergency Programme (Iodised oil) ii) Permanent Programme (Salt iodization Programme) 6.2) Conduct Programme Evaluation i) Emergency Programme (Iodised Oil) ii) Permanent Programme (Salt Iodization Programme)	6.1) NCCIDD has overall programme responsibility i) IDD Control Unit ii) IDD Control Unit 6.2) NCCIDD has overall programme responsibility i) IDD Control Unit ii) IDD Control Unit

21. RESOURCES

This chapter lists sources for further information and help.

A. Technical information on salt iodization

1. Salt Institute - Works to increase public awareness of the benefits of salt and salt products, promotes participation in public policy as it relates to salt products, fosters research in ice and snow control, agricultural feeding practices, water treatment, and salt in nutrition, conducts public information program, maintains technical data, centre on salt-related materials, sponsors industry safety contest; bestows Excellence in Storage Awards. 700 N. Fairfax Street, Suite 600, Alexandria, VA 22314-2040, phone (703) 549-4648, fax (703) 548-2194, Richard L. Hanneman, President.

2. European Salt Producers Association (ESPA) - Salt producers from 13 countries, defends members' interests, provides representation for producers before European and international bodies, maintains a documentation centre to facilitate technical advancement in the salt industry, commissions, advisory, medical. Committees: De-Icing Salt; Food Grade Salt; Standardization; Water Softening. Publications: Bulletin, annual; Directory, periodic; Newsletter, quarterly; *Salt Echo*, periodic; *Salt Throughout the World*, annual. Contains information on technical matters, medical matters, and patents. Conventions/Meetings: annual meeting. Bernard Moinier, Secretary General, 17, rue Daru, 75008 Paris, France, phone: 47665290; fax: 47665266.

3. ICCIDD maintains a list of technical experts on salt iodization; for information and advice, contact Mr. Mannar at the Micronutrient Initiative (International Development Research Centre (IDRC), BP 8500, 250 Albert Street, Ottawa K1G 3H9, Canada), fax: 613-567-4349.

B. Information on supplies

Annex 5 lists details from the UNICEF supply division. In addition, other machines are made locally, and further information may be available from UNICEF representatives in specific countries or from ICCIDD regional coordinators.

C. Other information on IDD

The following organizations are active in promoting elimination of IDD.

1. ICCIDD (International Council for Control of Iodine Deficiency Disorders) - This nonprofit international organizations exists to eliminate iodine deficiency disorders. Its members include physicians, public health workers, salt specialists, economists, communication experts, nutritionists, members of international agencies, and others.

ICCIDD operates through a board including an Executive Committee, four officers, and regional coordinators. Any of these individuals can be contacted for more information.

ICCIDD BOARD

Executive Committee

J. B. Stanbury (USA), Chairman
M. Benmiloud (Algeria), Vice Chairman
B. S. Hetzel (Australia), Executive Director
J. T. Dunn (USA), Secretary
M. G. Venkatesh Mannar (Canada/India)
G. A. Medeiros-Neto (Brazil)
C. Thilly (Belgium)

Regional Coordinators

Africa - M. Benmiloud (Algeria)
Central - D. Lantum (Cameroon)
Southeast - J. Mutamba (Zimbabwe)
West - O. L. Ekpechi (Nigeria)

Americas - E. Pretell (Peru)

Europe - F. Delange (Belgium)

South Asia - C. S. Pandav (India)

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R. Mohan (India)
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S. Ouais (Syria)
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Dr. Ma Tai
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People's Republic of China
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2. Micronutrient Initiative - The Micronutrient Initiative (MI) was established in 1992 as an international secretariat in Ottawa, Canada by its principal sponsors: Canadian International Development Agency, International Development Research Centre, United Nations Children's Fund and United Nations Development Programme and the World Bank. The mission of the MI is to catalyze the sustainable control of micronutrient malnutrition by the year 2000 in keeping with the goals of the World Summit for children and the International Conference on Nutrition. The MI recognizes that solutions to overcome micronutrient deficiencies need to go well beyond traditional health and nutrition systems. MI's support is guided by national strategies and expert consensus regarding viable and sustainable interventions for each of the three micronutrients. The MI focuses attention on five areas considered critical to national and global efforts in eliminating micronutrient malnutrition: advocacy and alliance building, development of sustainable interventions, support for effective programmatic actions, capacity building and the resolution of key operational issues. Contact address: Micronutrient Initiative Secretariat, c/o IDRC, P. O. Box 8500, Ottawa, Ontario, Canada, phone: 613-236-6163; fax: 613-567-4349.

3. UNICEF and the World Health Organization - Both these organizations are heavily involved in the elimination of iodine deficiency. UNICEF has a particularly strong focus on universal salt iodization and is active throughout the world. The country offices can be contacted for further information about iodine deficiency and universal salt iodization. Addresses at headquarters are:

(a) Health and Nutrition Division, UNICEF, UNICEF House, 3 United Nations Plaza, H-10F, New York, NY 10017, fax #212-326-7336,

(b) World Health Organization, Nutrition Division, 1211 Geneva 27, Switzerland, fax: 41-22-791-4156.

4. In many countries and regions, private salt producers have national or international organizations. These can be contacted for further information.

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ANNEX 1 - CHECKLIST FOR CONDUCTING A SALT SITUATION ANALYSIS

The situation analysis should cover the major areas and information needs as outlined below:

A1.1 IDD prevalence

A brief description of each of the latest studies on IDD prevalence in different regions of the country (clinical and biochemical) indicating date of study, population group, type of sample and its representativeness, the clinical classification method used and the clinical and laboratory results.

A1.2 Current salt production, Importation, and Refining

- a) Salt is produced from a variety of sources and could be available from both domestic and foreign sources. A quantitative summary of sources is the first step in making a country assessment. Overall status of salt production, importation/exportation and consumption in the country could be presented in the following format:

Origin	Availability	Rock salt	Lake salt	Sea salt	Other	Total
a. From within the country						
b. By import						
c. Export						
Net (a+b-c)						

- b) In countries with a limited number of producers, a listing of major salt producers and/or importers in the country and quantities handled annually. Where there are multiple (several hundreds or thousands) of producers, a listing of major production centres, grades of salt produced and size of individual units and number of producers in each category.

Name and location of production centre	Grades of salt types and quantities	Size of individual units	Number of producers in each category

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c) Where applicable, details of imports are to be provided:

Point of Import	Names of major importers	Sources (country) and quantities	Grades of salt imported and quantities

d) Where applicable, names of countries and the quantities of salt (iodized and non-iodized) exported yearly to each foreign country. Standards for and types of controls, if any, of imported and exported salt.

e) Current use of salt available (Production+Imports-Exports) should be presented:

Application	Iodized	Non-iodized	Total
Human			
Animal			
Industrial			

A1.3 Salt refining and iodization

a) Information needs to be collected on the consumption of crude and refined salt, location and capacities of refineries and a description of the refining process.

b) Where iodization is already being done, a brief description of the processes by which salt is iodized in the country (wet, dry, etc), the iodine compound used (iodide, iodate, etc) the stabiliser if any added to the iodine compound, the type of machine used, the required level of iodization and the actual level reached in each plant, control procedures in the plant and intervals at which carried out, the packaging and the coverage.

- c) A list of all iodization factories, capacities and actual production (for most recent year):

Name of iodization factory	Location	Iodized salt production capacity	Iodized salt produced

- d) An estimate of the cost of iodization per ton of iodized salt.
- e) Details of procurement and distribution of potassium iodate, quantity and prices

A1.4 Distribution and Marketing of salt

- a) A brief description of the major distribution channels for salt within the country from production/importation points through wholesale centres to retail outlets, the marketing channels and systems, selling units and current prices.
- b) Transport mechanisms, location of major wholesale and warehousing centres, quantities handled at each centre, storage and handling practices, packaging or repacking practices
- c) Prices for different grades and packing at production, wholesale and retail levels
- d) Government incentives and subsidy programmes if any
- e) Constraints to free market pricing and marketing activities

A1.5 Salt Consumption

- a) A brief review of salt consumption practices including an estimate of daily consumption rates, consumer preferences for different types of salt, cultural practices with regard to purchase, storage and utilization; factors affecting stability of iodine in the salt in households

A1.6 Advocacy and consumer education

- a) Assessment of the level of commitment at different levels, support of key influential groups such as medical associations or consumer associations
- b) Programmes and activities, if any, for informing and motivating the general public (or professionals or other specific groups) on IDD and the use of iodized salt.

- c) Consumer education efforts and capacity of government and the private sector to influence consumer purchase of iodized salt

A1.7 Administration,

- a) Administrative structure for overseeing and monitoring the programme

A1.8 Monitoring and regulation

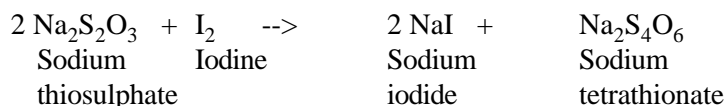
- a) Standards for iodine content in salt at factory, retail stores and households
- b) Mechanism for monitoring iodine levels in salt at different levels
- c) Current legislation and regulation affecting salt iodization: current standards and those currently enforced for the control of salt iodization, the responsible agencies, the intervals at which the controls are practised, the procedures (sampling location, collection methods, laboratory techniques) the coverage of the control programme (countrywide or limited to certain provinces/states)
- d) Enforcement mechanism for legislation at the production, wholesale and retail levels
- e) Number of samples analyzed by place of collection and iodine levels found (frequencies of classes of levels in ppm if the analyses are quantitative). Measures taken if insufficient iodization levels are detected.
- f) Problems faced in the systematic control of iodization at the national level, the measures taken to solve them and those that should be taken.

ANNEX 2 - QUALITY CONTROL LABORATORY FOR IODIZED SALT

(Extract from: The Use of Iodized Salt in the Prevention of Iodine Deficiency Disorders - A handbook of monitoring and quality control. New Delhi, UNICEF/ROSCA, 1989)

A2.1 Principle

The iodine content in iodized salt containing potassium iodate is estimated by a process called iodometric titration. Free iodine reacts with sodium thiosulphate solution as follows:



Sulphuric acid is added to a solution of iodized salt liberating iodine, which is titrated with sodium thiosulphate. Starch is used as an external indicator. The potassium iodide solution is added to keep the iodine in the dissolved state.

A2.2 Preparation of reagents

1. 0.005 Normal Sodium thiosulphate ($\text{Na}_2\text{S}_2\text{O}_3$)

Dissolve 1.24 g sodium thiosulphate crystals ($\text{Na}_2\text{S}_2\text{O}_3 \cdot 5\text{H}_2\text{O}$) in 1 L boiled, double-distilled water. This volume is sufficient for testing 200 salt samples. Store in a cool, dark place. Properly stored, the solution can be kept for a few months. Standardize the sodium thiosulphate solution every three months using standard potassium iodate solution.

2. 2 N Sulphuric acid (H_2SO_4)

To 90 ml double-distilled water add 6.0 ml concentrated sulphuric acid (H_2SO_4) slowly. Add boiled, double-distilled water to make 100 ml. This volume is sufficient for 100 salt samples. Store in a cool dark place. The solution may be kept indefinitely.

Caution: To avoid violent and dangerous reaction always add the acid to water, never water to acid! Stir the solution while adding.

3. Potassium iodide (KI, AR)

Dissolve 100 g KI in 1 Litre of double-distilled water. This volume is sufficient for testing 200 salt samples. Store in a cool, dark place. Properly stored, the solution may be kept for 6 months.

4. Soluble chemical starch

Dissolve reagent-grade sodium chloride (NaCl) crystals in 100 ml boiled, double-distilled water. While stirring, add NaCl until no more dissolves. Heat the contents of the beaker till excess salt dissolves. While cooling the NaCl crystals will form on the sides of the beaker. When it is completely cooled, decant the supernatant into a clean bottle. This can be stored for 3 to 4 weeks.

Dissolve 1 g of chemical starch in 10 ml boiling double-distilled water. Continue to boil till it completely dissolves. Add the saturated NaCl solution to make 100 ml starch solution. This volume is sufficient for testing 20 salt samples. Prepare fresh starch solution every day since starch solution cannot be stored.

A2.3 Laboratory procedure

The procedure is as follows:

1. Carefully weigh 10 g of the salt to be tested;
2. Pour the salt into a 50 ml measuring cylinder;
3. Slowly add boiled, double-distilled water;
4. Shake to dissolve the salt completely;
5. Add more water to make 50 ml;
6. Pour the salt solution (50ml) into a conical flask with stopper;
7. Pipette out 1 ml of 2 N sulphuric acid and add this to the salt solution;
8. Pipette out 5 ml of 10% potassium iodide and add this to the salt solution;
(Do not pipette acid or KI by mouth!)
9. The solution turns yellow. Close the flask with the stopper and put it in the dark for 10 minutes. A closed box, cupboard or drawer may be used;
10. Pour 0.005N sodium thiosulphate solution into a burette;
11. Adjust the level in the burette to "0";
12. After 10 minutes, take the flask out of the dark box;
13. Shaking the flask, titrate the solution in the flask with sodium thiosulphate from the burette;
14. Stop titration as soon as the solution turns pale (becomes very light yellow);
15. Add a few drops (1 to 5 ml) of 1% starch solution to the flask;
16. The solution turns deep purple;
17. Continue titration until the purple coloration disappears and the solution becomes colourless;
18. Note the burette reading;
19. From the attached table, read the iodine content of the sample in parts per million

A2.4 Reporting

Iodine testing is easy and takes only about twenty minutes per sample. Maintaining accurate records is as important as the testing itself. The results are to be recorded in a register indicating:

- * date of testing,
- * sample number,
- * batch number of the salt,
- * date of iodization,
- * source of sample,
- * date of sampling, and finally,
- * level of iodine in the sample.

Daily reports of the findings are made and the supervisor is to be alerted if the iodine content is less than the prescribed level. Your report will lead to action to protect the consumer. Delay on your part will delay these actions and harm the consumer.

A list of laboratory equipment and reagents required for analysis of iodized salt and available as a standard kit through UNICEF Copenhagen is attached.

IODINE CONTENT (IN PARTS PER MILLION)

Burette Reading	Parts per million	Burette Reading	Parts per million	Burette Reading	Parts per million
0	0.0	4.0	42.3	8.0	84.6
0.1	1.1	4.1	43.4	8.1	85.7
0.2	2.1	4.2	44.4	8.2	86.8
0.3	3.2	4.3	45.5	8.3	87.8
0.4	4.3	4.4	46.6	8.4	88.9
0.5	5.3	4.5	47.6	8.5	89.9
0.6	6.3	4.6	48.7	8.6	91.0
0.7	7.4	4.7	49.7	8.7	92.0
0.8	8.5	4.8	50.8	8.8	93.1
0.9	9.5	4.9	51.9	8.9	94.2
1.0	10.6	5.0	52.9	9.0	95.2
1.1	11.6	5.1	54.0	9.1	96.3
1.2	12.7	5.2	55.0	9.2	97.3
1.3	13.8	5.3	56.1	9.3	98.4
1.4	14.8	5.4	57.1	9.4	99.5
1.5	15.9	5.5	58.2	9.5	100.5
1.6	16.9	5.6	59.2	9.6	101.6
1.7	18.0	5.7	60.3	9.7	102.6
1.8	19.0	5.8	61.4	9.8	103.7
1.9	20.1	5.9	62.4	9.9	104.7
2.0	21.2	6.0	63.5		
2.1	22.2	6.1	64.5		
2.2	23.3	6.2	65.6		
2.3	24.3	6.3	66.7		
2.4	25.4	6.4	67.7		
2.5	26.5	6.5	68.8		
2.6	27.5	6.6	69.8		
2.7	28.6	6.7	70.9		
2.8	29.6	6.8	71.9		
2.9	30.7	6.9	73.0		
3.0	31.7	7.0	74.1		
3.1	32.8	7.1	75.1		
3.2	33.9	7.2	76.2		
3.3	34.9	7.3	77.2		
3.4	36.0	7.4	78.3		
3.5	37.0	7.5	79.4		
3.6	38.1	7.6	80.4		
3.7	39.1	7.7	81.5		
3.8	40.2	7.8	82.5		
3.9	41.3	7.9	83.6		

Description		QTY	STOCK NO.	UNIT PRICE USD	TOTAL USD
1	Glass bottles with stoppers, 50 ml 250 ml	4 12	09-194-00 09-194-50	0.69 0.99	2.76 11.88
2	Measuring cylinder with stopper, 100ml	12	09-374-30	3.59	43.08
3	Flask, boiling, flat bottomed, 500ml	4	09-378-00	2.23	8.92
4	Flask Erlenmeyer, conical with stopper, 100ml	12	09-381-00	0.67	8.04
5	Funnel, lab, plain, 65mm diameter	4	09-450-00	1.24	4.96
6	Pipette, volumetric, 1ml	4	09-676-00	0.73	2.92
7	Pipette, volumetric, 5ml	4	09-679-05	0.83	3.32
8	Burette, with straight stopcock, 10ml	4	09-239-00	5.21	20.84
9	Burette stand	4	09-767-00	13.64	54.66
10	Balance, semi-analytical, 250g and 2mg w/o weights	1	09-045-20	182.81	182.81
11	Set of weights for above	1	09-108-62	100.39	100.39
12	Balance, double beam, trip-dapm, 2kg, sens 0.1g	1	09-049-90	103.99	103.99
13	Set of weights for above	1	09-108-30	80.95	80.95
14	Rods, stirring, flint glass, assorted	1	09-686-00	3.59	3.59
15	Desiccator plain Scheibler, i.d. 150x150mm	1	09-374-60	25.95	25.95
16	Sodium Thio Sulphate, Analar	500g		12.38	12.38
17	Potassium Iodide, Analar	500g	10-675-00	3.68	3.68
18	Soluble starch	500g		25.00	25.00
19	Potassium Iodate, Analar	500g		75.00	75.00
20	Watch glass, 75mm	12	09-888-00	0.42	0.42
21	Spatula, single blade, 150mm, SS	6	09-699-10	2.03	12.18
22	Hot-plate, 100W, 220V	1	20-004-02	29.52	29.52
23	Dropper bottle, glass, 25-60ml	6	09-190-00	0.70	4.20
24	Test tube, 10ml, plain	12	09-789-95	0.11	1.32
25	Beakers, Purex, 250ml	12	09-160-00	0.95	11.40

TOTAL			USD	838.68
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NB OPTIONAL

For conducting the tests distilled water must be used. Laboratories having no access to distilled water should request one of the following water stills:

26	Still, water, 2 ltr/0.5 gal per hour fuel-heated	1	01-680-02	148.22
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OR

27	Still, water, electrical, 4ltr/gal per hour 220V, 50/60 Hz, AC	1	06-676-00	1,156.08
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ANNEX 3 - FIELD TEST KITS FOR IODIZED SALT

The following kits to check salt iodized with potassium iodate and potassium iodide are available through UNICEF Copenhagen.

A. KITS FOR CHECKING SALT IODISED WITH POTASSIUM IODATE

A.1	FIELD TEST KIT FOR THE DETERMINATION OF POTASSIUM IODATE (K10) IN IODISED SALT. Three ampoules with test solution,0-50ppm One color chart One instruction leaflet Packed in a plastic container Labelled "For testing Salt Fortified with Potassium Iodate only"	UNICEF STOCK NO. 05-860-00	US\$ 0.40
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A.2	FIELD TEST KIT FOR THE DETERMINATION OF POTASSIUM IODATE (K10) IN IODISED SALT. Three ampoules with test solution,0-100ppm One color chart One instruction leaflet Packed in a plastic container Labelled "For testing Salt Fortified with Potassium Iodate only"	UNICEF STOCK NO. 05-860-01	US\$ 0.40
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B. FIELD TEST KITS FOR CHECKING SALT IODISED WITH POTASSIUM IODIDE:

Three ampoules with test solution, One color chart One instruction leaflet Packed in a plastic container Labelled "For testing Salt Fortified with Potassium Iodide only"	UNICEF STOCK NO. 05-860-02	US\$ 0.60
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C.	RE-CHECK SOLUTION FOR AREAS WHERE THERE IS ALKALINITY IN SALT. Three ampoules of re-check solution One instruction chart Packed in a plastic container Labelled "Re-check solution for checking alkaline salt"	UNICEF STOCK NO. 05-860-03	US\$ 0.36
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Please note that prices indicated above are FOB Madras, India.

NOTES:

1. Contact the UNICEF office in your country through the Ministry of Health and indicate requirements spelling out detailed specifications as above including relevant item number and clearly indicating whether the salt in your area is iodised with potassium iodate or potassium iodide.
2. For kits (A.1 or A.2) specify the range of PPM preferred, i.e. 0-50 or 0-100.
3. Some salts contain alkalinity in the form of carbonates. The alkalinity could also be caused by the presence of free flow agents in the salt. In such circumstances the test solution may not release the blue colour to indicate the presence of iodine in the salt. To solve this problem a recheck solution has been developed. In cases where there is suspicion of a possible alkalinity or where the normal test solution does not indicate a change of colour, a drop of the recheck solution may be used and the normal test solution may be dropped over this spot to indicate the presence of iodine. However, if the recheck solution is used in a salt sample without alkalinity followed by the normal solution, it will still indicate the correct iodine level.
4. The kits indicate whether the salt is fortified or not. A laboratory analysis is needed to determine the precise concentration of iodate or iodide.
5. The contents of the kits do contain dilute acid. Care should be taken not to spill solution on clothing, and they should be kept out of reach of children.
6. Each ampoule has 10 ml. of test solution which is sufficient for about 40-50 tests.
7. The solution has a shelf life of more than 18 months if unopened and 6 months after opening the ampoule.

ANNEX 4 - ECONOMICS OF SALT IODIZATION IN BANGLADESH: A CASE STUDY

The cost of salt iodization in Bangladesh have been comprehensively studied in the paper by Sajjad Zohir (Salt Iodization in Bangladesh - Estimates of incremental costs. UNICEF Dhaka 1992). The paper estimates the incremental cost of iodization covering the following components:

- A. Machinery and foundation cost amortization
- B. Rent of premises
- C. Other expenses
- D. Insurance premium
- E. Repair & maintenance
- F. Cost of finance
- G. Potassium iodate
- H. Electricity
- I. Labour
- J. Weight loss
- K. Impulse sealer amortization
- L. Packaging infrastructure
- M. Roller & dice
- N. Packing material cost including printing

The estimates are the costs incurred by the manufacturer and do not include cost of support measures such as social communications, monitoring, regulation and enforcement, program administration and coordination.

The cost has been estimated to range from a low of Tk 0.042/kg for 75 kg bags packing to a high of Tk 1.20/kg for 1 kg packets which is to be expected keeping in view the high material and labour cost for the smaller packets. The Zohir study findings are important for sustainability considerations and are annexed to this report.

Apparently, iodized salt is packed exclusively in 1 kg packets as a form of identification to justify an increase in price. In reality the mark up is quite substantial: Tk 8/kg (Tk 300-350 for 25 pack carton) for the packed salt vs Tk 5.3/kg (Tk 385-400/bag of 75 kg) for the bag salt. It should be noted that in both cases the quality of the salt is the same. The crushers believe that if they iodate the salt and fill it in the same 75 kg bags without any visible change in packing, they will not be able to demand a higher price (which is true given the extremely low incremental cost). When this issue was discussed with the crushers, they replied that when all salt is iodized, then bagged salt would also be iodized. The challenge would be to get the crushers to pack and market iodated salt in the 75 kg bags with a marginal price increase as early as possible (say Tk 20-30 for a bag). At the retail level, there should be no difference in price between iodized and uniodized salt initially. Eventually, all salt should be iodized.

Zohir has also summarized the cost to the producer under four scenarios:

Scenario	Basis	Validity	Cost (75 kg bag packing)* Tk/kg	Cost (1 kg retail pack)* Tk/kg
I	Variable cost only	Year 1	0.042 (0.093)	1.082 (1.13)
II	Var cost + annual & short period expenses	Years 1-3	0.043 (0.094)	1.083 (1.13)
III	Var Cost + annual + med term expenses	Years 3-6	0.052 (0.103)	1.13 (1.18)
IV	Var cost + annual + equipment & foundation replacement	Long term	0.12	1.20

* Figures in parentheses include cost of potassium iodate

These figures demonstrate the prima-facie feasibility of

- a) Total or phased withdrawal of iodate subsidy after 5 years (subject to a review at that time). The iodate subsidy amounts to only Tk 0.051/kg. While it provides an initial fillip to the program its influence on the overall costing is small. The iodate however, needs to be purchased in hard currency. Further, UNICEF by virtue of its large global purchases of iodate is able to negotiate the lowest prices for the chemical. Therefore, even after the subsidy is withdrawn and the cost passed on to the consumer, UNICEF assistance in procurement (possibly on a reimbursable basis by which GOB will reimburse UNICEF with the hard currency value of the chemical in local currency) would be beneficial. However, this implies continued UNICEF involvement, and it can be regarded only as a service that UNICEF is providing. Sustainability of the program will not be materially affected even if UNICEF were to withdraw.
- b) Machinery maintenance and eventual replacement at manufacturer's cost. since the machinery can be procured in local currency. Manufacturers are building in adequate margins in their price to be able to pay for future maintenance and replacements.

ANNEX 5 - SALT IODIZATION MACHINES AVAILABLE THROUGH UNICEF

The supply division of UNICEF in Copenhagen has provided the following specifications for salt iodization machines, as of August 31, 1994. Further information can be obtained from Velimir Srdanovic, Chief, Health and Nutrition Section, UNICEF Supply Division, UNICEF Plads, Freeport, 2100 Copenhagen OE, Denmark, phone: 45-35-273-527; fax: 45-35-269-421.

A5.1 EQUIPMENT FOR SALT IODIZATION

Continuous spray mixing equipment

The type of equipment recommended is based on a design originally made for UNICEF India over 20 years ago. This design has recently undergone significant modifications to make it much smaller and is now available as a stationary or mobile unit. There has been extensive experience with this design, in many countries of the world, and it has been shown to effectively iodise semi-refined, moist salt within acceptable limits. Semi dry refined salt (typically taken from large heaps which have been made to allow the salt to dry for several days) will be loaded manually into a hopper. The salt will be released from the hopper at a constant rate into a rotating screw mixer and will be sprayed with a fine spray of potassium iodate solution. The salt will be thoroughly mixed with the solution and then discharged through a chute into 60 kg bags which will be changed manually. (See Fig. A5.1.1 and A5.1.2).

A recent test of this kind of equipment in Bangladesh, using 'damp' salt dried by gravity for four days showed that 18 samples of salt collected over a period of 10 minutes had a mean iodine content of 29.7 ppm, a range of 27.5 to 31.7 and a standard deviation of 1.4. suggesting that this equipment would easily allow a manufacturer to comply with a regulation that specified an acceptable range of variation of 20 ppm (eg salt should contain not less than 40ppm and not more than 60 ppm).

Concern has also been expressed that potassium iodate in damp salt will 'migrate' towards the bottom of a sack. While the extent of migration could vary depending on salt quality and environmental condition, present experience indicates that this is not a major problem. In a recent test in India of crude solar salt stored in sack for one year, salt taken from the top of the bag was found to have 29.2 ppm iodine and that from the bottom of the bag 35.5ppm.

Batch type iodisation equipment for 10-30 tons/day

For this capacity a stationary ribbon blender is available. A batch of 125 - 250 kg is loaded into a U shaped mixing trough and while spreading a metered dose of potassium iodate mixing takes place by the movement of the ribbons.

Mixing time needed is approx 5 minutes after which the salt is discharged through manually operated gate at the bottom of the blender. (See Fig. A5.1.3).

Batch type iodisation equipment less than 10 tons per day

For this type two designs are available in an experimental stage and work on the principle of removable drums which rotate either in a holder or on two supporting rollers. 50 kg of salt is loaded into an inclined mixing barrel, a measured amount of potassium iodate solution is then sprayed onto the salt and the mixing barrel is then rotated for a period of 5 minutes to ensure thorough mixing. The iodised salt is then emptied out of the barrel and packed, and a further load of salt placed in the barrel. The use of

many preloaded mixing barrels will ensure the efficient use of the mixer. (See Fig. A5.1.4 and A5.1.5). It should be noted that these machines are restricted to mix 600 - 700 kg/hr because of the handling capacity : 50kg per batch. In order to reach 2 tonnes per hour it is advisable to double or triple the number of machines. These types have not yet been sufficiently tested to assure acceptable performance however, initial test runs reveal that they have a good potential to serve the smaller factories at a significant lower cost.

A5.2 DRIP FEED IODIZATION METHOD FOR SALT GRINDERS

In many cases salt is run through grinders in the process of refining. In India it has been proven that by drip feeding a iodine solution just before the salt enters into the grinder gives good results in terms of dosage and homogeneity can be achieved. The only necessary equipment required is a metered drip feeder attached to the outlet of the salt feeding hopper of the grinder. Capacity of such grinders is usually in the range 1 - 5 tons per hour. This system is recommended whenever a grinding facility already exists. The cost of setting up the drip feed system is very small.

In Bolivia this system is used predominantly but then using the dry method: a premix of potassium iodate enters with the salt in the grinder. Homogeneity within the final iodized product can be improved by adding a simple mixing device after milling.

Before deciding to buy complete iodisation machines it is of utmost importance to analyse the current existing factory processes since with little addition to those processes, the same can be achieved as with adding a complete Salt Iodisation Machine. (See Fig. A5.2.1).

A5.3 PACKAGING EQUIPMENT

Bulk Bag Packing

Bulk bags of 20 - 50 kg capacity can be packed in two ways:

- a) Hand operated bag stitching machine with Coil spring suspension unit.
Approx. cost USD 2500
- b) Stitching machine with sewing head and horizontal chain and slat conveyor (2-2.5 m length) synchronised with sewing head, with hand-operated knife and foot-switch control and fitted with adjustable backrest. Sack to be entered into the sewing head which automatically starts, sews, cuts the stitching thread and stops again ready for the next sack, with inclined belt conveyor.
Approx. cost USD 25.000

Retail Packing

There is a definite trend to pack iodized salt in retail packs of 1/2 or 1 kg polyethylene bags, The filling and sealing of the bags can be done in one of the following ways:

- a) Semi automatic filling and sealing machine
- (i) Feed hopper and foot operated filling spout. When the foot-switch is pressed, one fill is obtained. The weight of each fill can be preset. Capacity 10-15 bags/min or 600 - 750 kg/hour.
 - (ii) Sealing machine with electrically operated foot-switch to seal the filled bags. Capacity 10-15 bags/min or 600 - 750 kg/hour.

Cost of filling machine approx \$ 5000 and sealing machine \$ 2000.

- b) Automatic form fill and seal machine

Machine consisting of a volumetric feed unit and a packaging film forming shoulder and filling tube where polyethylene film is folded and sealed-vertically as a tube. The volumetric feed unit delivers a controlled volume of salt as demanded by the packaging machine. The film is then moved downwards to the length required, filled with salt and the top sealed. This sealing action also seals the bottom of the following empty bag. The size of the bag can be adjusted during the operation. The filled bags are carried away by a small conveyor to a packing table where they are manually packed into cardboard boxes. The filling accuracy is +/- 1%. Machine capacity 35-40 bags/min or 2-2.5 tons/hour. The cost of the machine is approx \$ 25,000. Cost of 60 bags/min machine is about \$42,000.

A5.4 ANCILLARY EQUIPMENT OPTIONAL

Wood Deck Platform truck with four rubber tyres

2 swivel type and 2 fixed type
Capacity : 500 kgs
Price : \$ 200

Weigh balance - platform type

Capacity : 200 kgs
Price : \$ 300

5 KVA diesel generating set

with diesel engine, alternator, control panel
switch gear and accessories, mounted on common
base plate.
Price : \$ 4000

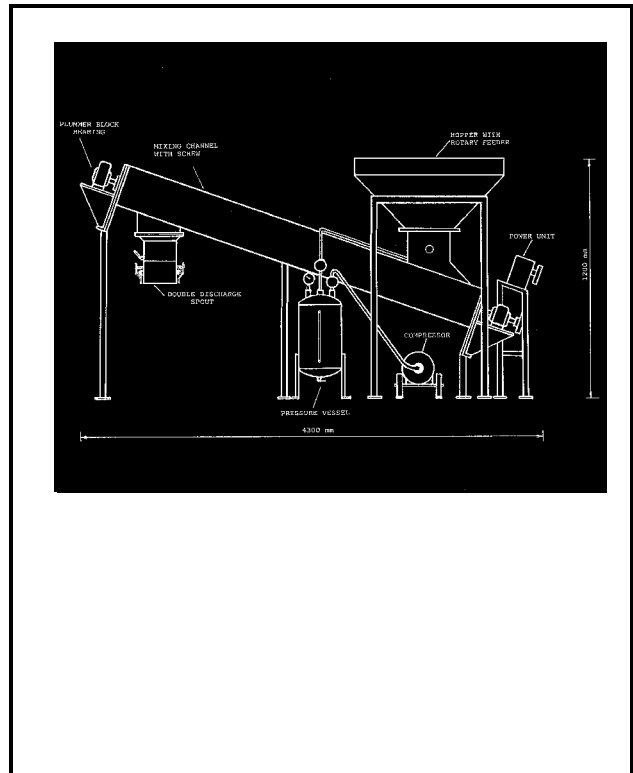


Fig. A5.1.1 CONTINUOUS SPRAY SALT IODIZATION MACHINE

STATIONARY TYPE

FUNCTION: To spray and mix a solution of Potassium Iodate with salt

DESCRIPTION: The machine consists of the following components:
 Feed Hopper
 Spraying unit with compressor
 Inclined Screw mixer with Power unit
 Supporting Structure
 Control Unit

OPERATION: The salt is loaded into the feed hopper and falls through a controlled rotary feeder into a mixing chamber. While falling, the salt is sprayed with a solution of potassium iodate injected from nozzles in the spraying chamber. The mixing chamber is an inclined channel in which a canted helicoidal spindle rotates, mixing and transporting the salt upwards. At the end of the channel is a twin outlet to discharge the salt into bags. The mixers are to be preset at ranges from 20-100pp.m in accordance to country specifications.

- CAPACITY:*** **5 - 9 tonnes per hour.**
This capacity is variable according to the loading and bagging facilities. This rating gives at 8hrs/day and 250 days/year an annual output of 10.000-18.000 tonnes.
- DIMENSIONS:*** **L x W x H : 4.3M x 2M x 1.2M**
- MATERIALS:*** All metal in touch with iodine and salt is made out of high grade AISI304 stainless steel, all other made of heavy duty coated mild steel. Bearings to be self aligning and sealed.
- ENERGY REQ.:*** The machine is driven either by a 3HP 3 phase electric motor or a 5-7 HP diesel engine.
- PRICE RANGE:** USD 7.000 - 10.000

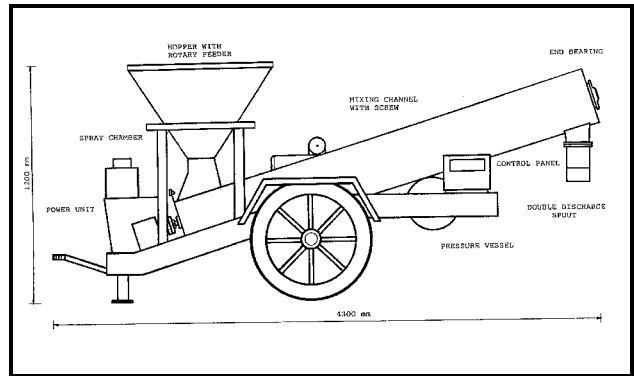


Fig. A5.1.2 CONTINUOUS SPRAY SALT IODIZATION MACHINE

MOBILE TYPE

- FUNCTION:** To spray and mix a solution of Potassium Iodate with Salt
- DESCRIPTION:** The machine consists of the following components:
 Feed Hopper
 Spraying unit with compressor
 Inclined Screw mixer with Power unit
 Supporting Structure
 Control Unit
- OPERATION:** The salt is loaded into the feed hopper and falls through a controlled rotary feeder into a mixing chamber. While falling, the salt is sprayed with a solution of potassium iodate injected from nozzles in the spraying chamber. The mixing chamber is an inclined channel in which a carted helicoical spindle rotates, mixing and transporting the salt upwards. At the end of the channel is a twin outlet to discharge the salt into bags. The mixers are to be preset at ranges from 20-100pp.m in accordance to country specifications.
- CAPACITY:** **5 - 9 tonnes per hour.**
 This capacity is variable according to the loading and bagging facilities. This rating gives at 8hrs/day and 250 days/year an annual output of 10.000-18.000 tonnes.
- DIMENSIONS:** **L x W x H : 4.3M x 2M x 1.2M**
- MATERIALS:** All metal in touch with iodine and salt is made out of high grade AISI304 stainless steel, all other made of heavy duty coated mild steel. Bearings to be self aligning and sealed.
- ENERGY REQ.:** The machine is driven either by a 3HP 3 phase electric motor or a 5-7 HP diesel engine.

PRICE RANGE: USD 7.000 - 10.000

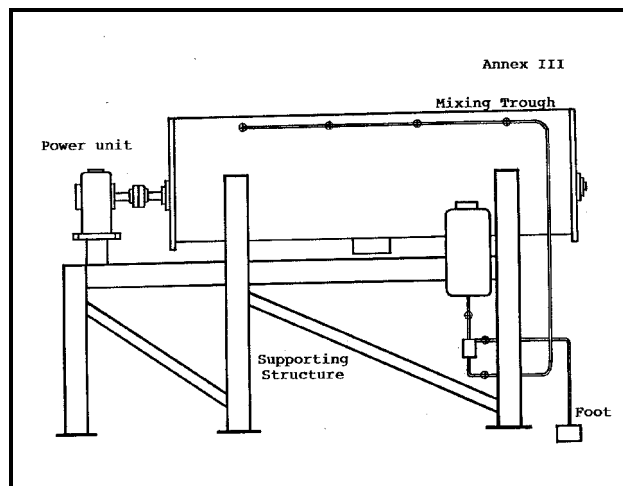


Fig. A5.1.3 RIBBON BLENDER SALT IODIZATION MACHINE

BATCH TYPE

FUNCTION: To spray and mix a solution of Potassium Iodate with Salt.

DESCRIPTION: The machine consists of the following components:
U shaped mixing trough with blender ribbons
Food operated compression spraying unit
Power unit with reduction gear
Supporting structure

OPERATION: The salt is loaded in to the mixing trough and a metered dose of Potassium Iodate solution is sprayed on the salt while the blender ribbons are moving. The salt is mixed for five minutes after which time the mixture is homogeneous. The discharge chute is manually opened and the salt is emptied into bags from under the body.

CAPACITY: 125/250 kg batch capacity. Output mainly depending on the loading and unloading facilities
1-2 tons/hr.

DIMENSIONS: 125 kg : L x W x H : 2.5 M x 1.0 M x 1.6 M
250 kg : L x W x H : 3.5 M x 1.2 M x 1.8 M

MATERIALS: All materials in touch with salt or the solution Stainless Steel SS304 . The body is made out of steel with a chlorinated rubber paint coating.

ENERGY REQ. 250 KG 5 HP / 3.75 KW
125 KG 3 HP / 2.20 KW

PRICE RANGE : 250 KG \$ 3.500

125 KG \$ 2.500

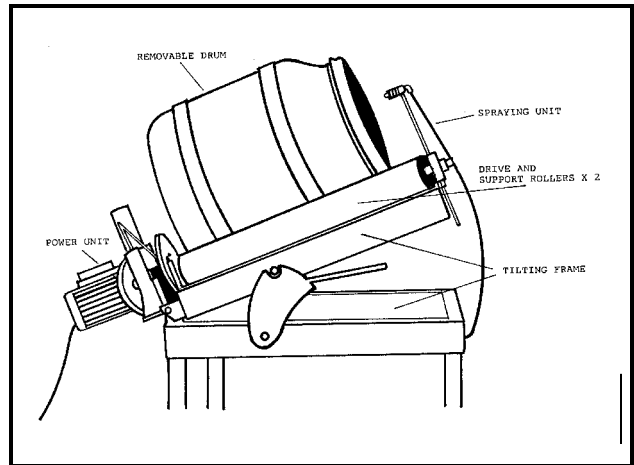


Fig. A5.1.4 ROLLER DRUM SALT IODIZATION MACHINE

BATCH TYPE

FUNCTION: To spray and mix a solution of Potassium Iodate with Salt

DESCRIPTION: The machine consists of the following components:
 Removable polyethylene drum
 Tilting frame with two rollers and power unit
 Iodine solution reservoir with metering pump and spraying unit.

OPERATION: The salt is loaded in a removable drum up to 60 kg per charge, The drum is positioned on the rollers, and while rotating, the solution of potassium iodate is sprayed over the salt inside the drum. The unit is set to spray the specific required amount of potassium iodine solution over the salt. The drum is left to turn for 5 minutes after which time the salt is homogeneously mixed.

CAPACITY: Varying, depending on the size of drums. 600 - 1000 kg/hrs and the lifting capacity of the manpower.

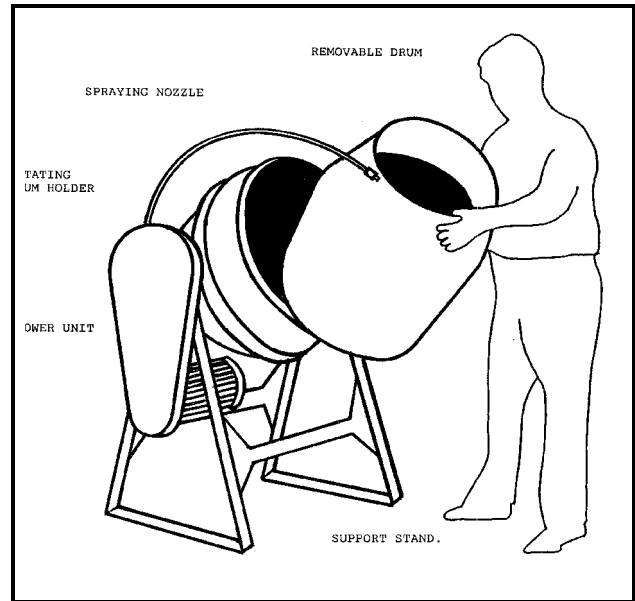
DIMENSIONS: L x W x H : 1.5 M x 0.75 M x 1 M

MATERIALS: Supporting structure made out of heavy coated mild steel while mixing drum is of polyethylene.

ENERGY REQ.: The machine is powered by a 200 watt, 220 volt electromotor or 4 Hp petrol engine.

PRICE RANGE: USD 1,500

NOTE: This design is still in an experimental stage but is promising.



**Fig. A5.1.5 ROTARY DRUM SALT IODIZATION MACHINE
BATCH TYPE**

- FUNCTION:** To spray and mix a solution of Potassium Iodate with Salt
- DESCRIPTION:** The machine consists of the following components:
Removable polyethylene drum
Rotating drum holder with support stand and power unit
Iodine solution reservoir with metering pump and spraying unit.
- OPERATION:** The salt is loaded in a removable drum up to 60 kg per charge, The drum is positioned in the drumholder, and while rotating, the solution of potassium iodate is sprayed over the salt inside the drum. The unit is set to spray the specific required amount of iodine solution over the salt. The drum is left to turn for 5 minutes after which time the salt is homogeneously mixed.
- CAPACITY:** Varying, depending on the size of drums. 600 - 2000 kg/hrs and the lifting capacity of the manpower.
- DIMENSIONS:** **L x W x H : 1.5 M x 0.75 M x 1 M**
- MATERIALS:** Supporting structure made out of heavy coated mild steel while mixing drum is of polyethylene.
- ENERGY REQ.:** The machine is powered by a 200 watt, 220 volt electromotor or 5 Hp petrol engine.
- PRICE RANGE:** USD 2.000
- NOTE:** This design is still in an experimental stage but is promising.

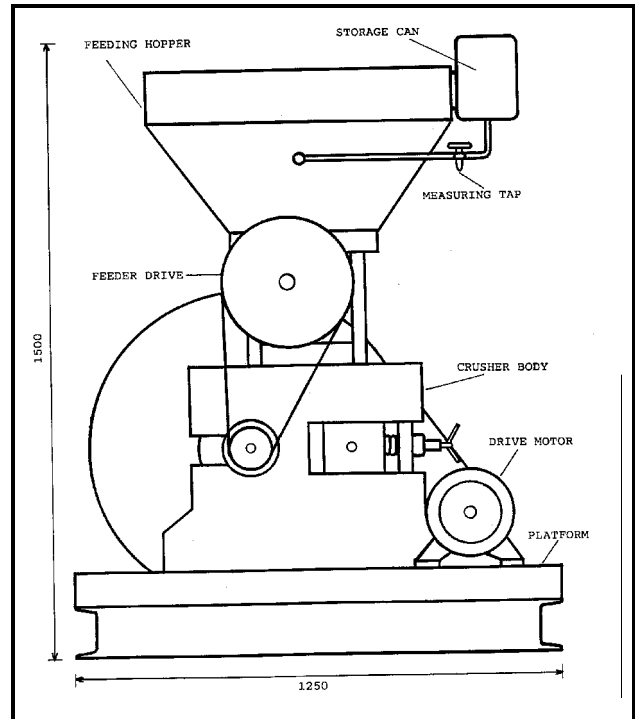


Fig. A5.2.1 SALT GRINDER WITH DRIP FEED ATTACHMENT

- FUNCTION:** To mix Iodate with salt while grinding/crushing the salt.
- DESCRIPTION:** The machine consists of the following components:
 Feeding hopper with dripfeed attachment
 Feeder drive
 Crusher body with rollers
 Drive motor
 Platform
- OPERATION:** The Iodate solution is drip fed into the salt receiving hopper and while crushed between the roller mixed with the small granulated salt.
 The salt should be less than 4% moisture content.
- CAPACITY:** Up to 5 tonnes/hr.
- DIMENSIONS:** **L x W x H : 1.5 M x 1.4 M x 1.5 M**
- MATERIALS:** All materials in direct contact with salt is made of stainless steel. The rollers are of high rate carbon cast iron. The hopper sometimes is made out of wood.
- ENERGY REQ.** 15 HP electric or diesel motor
 125 KG 3 HP / 2.20 KW
- PRICE RANGE :** US\$ 6500 for 4-5 tons per hour