

S-A-L-T AS SUPPORTIVE AND LUCRATIVE TASTE

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Article Received on 15/03/2018

Article Revised on 05/04/2018

Article Accepted on 26/04/2018

ABSTRACT

Iodized white salt (commonly available in the country) is chemically processed and bleached from yellowish/off-white color to white color as it undergoes processing to convert brine from sea water to white salt with chemicals added for Iodine fortification and anti-caking agents like E551 (nanosilica; SiO_2) & E536 (potassium ferrocyanide; $\text{K}_4[\text{Fe}(\text{CN})_6]$). It is different from the natural sea salt or rock salt which is natural, unrefined healthier options. An image is attached for more clarity around the process. An anti-caking agent is an additive placed in powdered or granulated materials, such as table salt or confectionaries to prevent the formation of lumps (caking) and for easing packaging, transport, and consumption. There is no evidence to suggest there are any negative health effects. In fact, studies have shown it to boost immune function, reduce mortality and help with weight loss. An anti-caking agent in salt is denoted in the ingredients, for example, as "anti-caking agent (554)", which is sodium aluminosilicate, a man-made product. This product is present in many commercial table salts as well as dried milk, egg mixes, sugar products, flours and spices. In Europe, sodium ferrocyanide (535) and potassium ferrocyanide (536) are more common anti-caking agents in table salt. "Natural" anti-caking agents used in more expensive table salt include calcium carbonate and magnesium carbonate. Some anti-caking agents are soluble in water, while others are soluble in alcohols or other organic solvents. They function either by absorbing excess moisture or by coating particles and making them water-repellent. Calcium silicate (CaSiO_3), a commonly used anti-caking agent, added to e.g. table salt, absorbs both water and oil. Anti-caking agents are also used in non-food items such as road salt, fertilizers, cosmetics, synthetic detergents, and in manufacturing applications.



The most widely used anti-caking agents include the stearates of calcium and magnesium, silica and various silicates, talc, as well as flour and starch. Ferrocyanides are used for table salt. The following anti-caking agents are listed in order by their number in the Codex Alimentarius:

tricalcium phosphate ($\text{Ca}_3(\text{PO}_4)_2$:341), powdered cellulose ($\text{C}_6\text{H}_{10}\text{O}_5$)_n: 460), magnesium stearate ($\text{Mg}(\text{C}_{18}\text{H}_{35}\text{O}_2)_2$: 470b), sodium bicarbonate (NaHCO_3 : 500), sodium ferrocyanide ($\text{Na}_4\text{Fe}(\text{CN})_6 \cdot 10\text{H}_2\text{O}$: 535), potassium ferrocyanide ($\text{K}_4[\text{Fe}(\text{CN})_6] \cdot 3\text{H}_2\text{O}$: 536), calcium ferrocyanide ($\text{Ca}_2\text{Fe}(\text{CN})_6 \cdot 12\text{H}_2\text{O}$: 538), calcium phosphate ($\text{Ca}_3(\text{PO}_4)_2$: 542), sodium silicate ($\text{Na}_2\text{SiO}_2 \cdot n\text{H}_2\text{O}$: 550), silicon dioxide (SiO_2 : 551), calcium silicate (Ca_2SiO_4 : 552), magnesium trisilicate ($\text{Mg}_2\text{O}_8\text{Si}_3$: 553a), talcum powder ($\text{Mg}_3\text{Si}_4\text{O}_{10}(\text{OH})_2$: 553b), sodium aluminosilicate (554), potassium aluminium silicate (555), calcium aluminosilicate ($\text{Na}_2\text{Al}_2\text{Si}_4\text{O}_{32} \cdot 3\text{H}_2\text{O}$: 556), bentonite (558), aluminium silicate ($x\text{Al}_2\text{O}_3 \cdot y\text{SiO}_2 \cdot z\text{H}_2\text{O}$: 559), 570 stearic acid ($\text{C}_{17}\text{H}_{35}\text{COOH}$: 570), polydimethylsiloxane ($\text{C}_2\text{H}_6\text{OSi}$)_n: 900).

KEYWORDS: Sodium chloride, Anti-caking agents, Evaporation, Brine, Sea Water, Salt Lakes, Sub Soil, Rock Salt, Black salt, Iodized salt.

INTRODUCTION

Sodium chloride (NaCl), also known as salt, common salt, table salt or halite, is an ionic compound. Salt is most widely distributed inorganic compound throughout the world. It is responsible for the salinity of the ocean and of the extracellular fluid of many multi-cellular organisms. It is a part of human food and life without salt is probably impossible. Other living beings, such as animals, also require salt for their growth. In India, about 70% of the salt is consumed by human being and rest 30% is used in the manufacture of chemicals. Salt is the basic raw material for the caustic soda and chlorine, soda ash (sodium carbonate), sodium sulfate, hydrochloric acid etc. Salt is also used in a large number of other industries, such as hydrogenation of oil, manufacture of soap, dyes, textile, food processing etc.^[1]

SOURCES OF SODIUM CHLORIDE

1. **Sea Water:** As the India has one of the largest seashore in the world, salt manufacture sites are spread throughout the country. Main salt

manufacturing centers are Gujarat, Maharashtra, Tamilnadu, Kerala, Andhra Pradesh, Karnataka, Orissa and West Bengal. About 70% of the total salt production comes from sea water.

2. **Salt Lakes:** There are two important salt lakes in India. Sambhar lake in Rajasthan and Chilka lake on eastern coast. Sambhar lake produce more than 2.5 lakh tones of common salt every year.
3. **Sub Soil:** Water which contains more salt than the sea water that is why, is becoming an important source of salt in the country. Leading salt manufacture sites form sub soil water are Kharagoda, Didwana, Dharangadhra and Tucticorin.
4. **Rock Salt:** Rock salt is used during religious festivals mainly produced in Mandi (Himachal Pradesh).

MANUFACTURE

Salt obtained from above sources 1, 2, or 3 is in solution or liquid form. This form is called as brine. The various methods used for concentrating the brine solutions are:

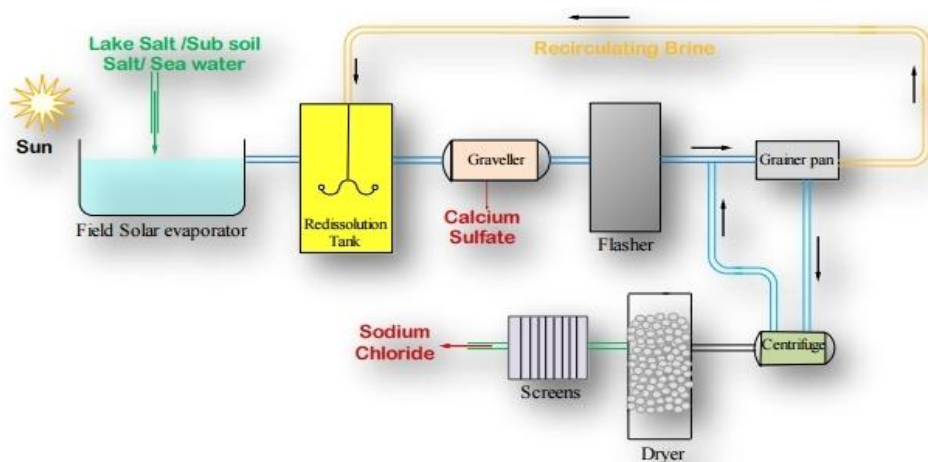


Figure-1: Salt manufacture by solar evaporation.

1. **Solar Evaporation:** It is the cheapest and best method of manufacturing salt from the brines. Brine is a high-concentration solution of salt (usually sodium chloride) in water. In different contexts, brine may refer to salt solutions ranging from about 3.5% (a typical concentration of seawater, on the lower end of solutions used for brining foods) up to about 26% (a typical saturated solution, depending on temperature). Lower levels of concentration are called by different names: fresh water, brackish water and saline water. Brine naturally occurs on Earth's surface (salt lakes), crust, and within brine pools on ocean bottom. High-concentration brine lakes typically emerge due to evaporation of ground saline water on high ambient temperatures. Brine is used for food processing and cooking (pickling and brining), for de-icing of roads and other structures, and in a number of technological processes. It is also a by-product of many industrial processes, such as desalination, and may pose an environmental risk due to its corrosive and toxic effects, so it requires wastewater

treatment for proper disposal. This method has widely been used in India. Sea brine (3-3.5°Be) is first conveyed to a reservoir through channels to store brine, remove suspended impurities and to concentrate the brine from original, 3- 3.5°Be to about 10°Be by solar energy. The reservoir is usually kept at a certain height, where brine flows under gravity. The 10°Be brine is again concentrated to 25°Be brine by solar evaporation by passing it to condensers through the channels. Due to evaporation of water from brine the solution gradually concentrates and different impurities separate out at different concentration as follows: 1 °Ré = 1.25 °C

1. At 7.5°Be ferrous iron present separates out as ferric oxide: At 10°Be, calcium carbonate precipitates out.
2. At 12-25°Be, calcium sulfate precipitated out.
3. At the 25°Be brine from the condensers is now passed on to the crystallizes, where salt crystallizes from 25.4°Be to 30°Be and other impurities also start separating. Salt form the solar evaporation method may be purified by dissolving it in purified

brine or water then crystallize in grainer which is open pan having 15-20ft width, 150-200ft length and 2ft depth. Beneath the submerged coils is a system of reciprocating rakes for the salt removal. Evaporation takes place in grainer at 95-100°C.

Flat hopper shaped crystals formed on the surface and then fall to bottom of the grainer, where the crystal grow further before removed by rack system. The wet crystal are centrifuged, dried and screened. 99.98% NaCl can be obtained, if the incoming brine treated properly. The mother liquor (bittern) is separated for the recovery of other by products. The main constituents of bittern are NaCl, MgCl₂, MgSO₄, KCl and Br₂.^[2]

Major engineering problem

The factors which influence solar evaporation are as under:

1. Absorption of solar energy
2. Air humidity
3. Temperature
4. Wind velocity

Suitable dyes or black sand are used to increase the rate of absorption of solar energy and thereby increase the

evaporation rate. Suitable soil stabilization is necessary for the open brine condensers and crystallizers to reduce seepage and increasing their bearing strength for mechanical harvesting of salt crystals. In modern salt farms soil is stabilized by blending the soil with salt, gypsum, bentonite and lined with bricks, bituminous plaster and plastic films. Heavy mechanical salt harvesters are used for gathering salts.

2. Artificial Evaporation:

Raw material: Saturated brine = 3450kg, Soda ash (58%) = 3.5kg, Caustic soda (50%) = 0.375kg, Steam = 1135kg (for triple effect evaporator)

MANUFACTURE

Artificial evaporation was carried out in open pans but it is now carried out in vacuum pans, known as vacuum evaporation methods. In this method, brine is boiled under reduced pressure in vacuum pan in order to get cubical grains of salt.

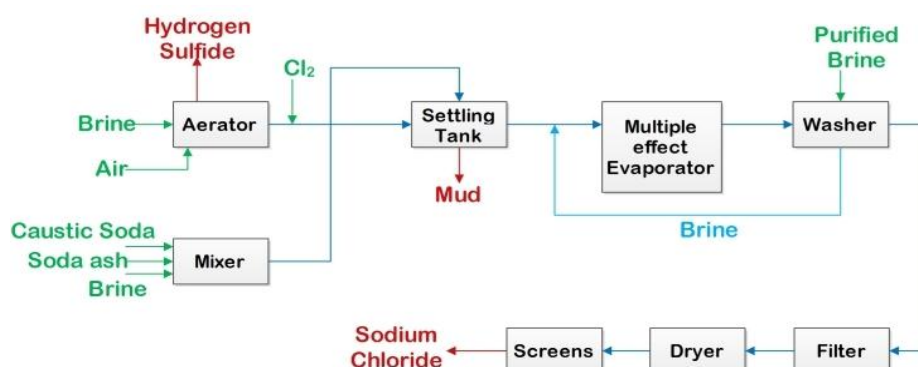


Figure-2: Salt manufacture by chemical process.

Brine is first aerated to remove H₂S. Addition of chloride removes the last traces of H₂S and oxidize ferrous ion (Fe²⁺) to ferric ion (Fe³⁺). Then brine sent to settling tank where it is treated with dilute solution of caustic soda (NaOH) and soda ash (Na₂CO₃) to remove most of calcium (Ca²⁺), magnesium (Mg²⁺) and ferric ions (Fe³⁺). Purified brine is pumped to the vacuum pans, where calcium sulfate (CaSO₄) is removed as a result of counter

current flow and hydraulic washing with brine. The vacuum pan evaporators are usually triple effect evaporators made of cast iron steel sheets and copper tubes. Salt slurry is continuously drawn from each evaporator through the salt leg at the bottom of which brine is feed so that the salt slurry is washed by incoming brine, thus washing back the impurities into the pans.

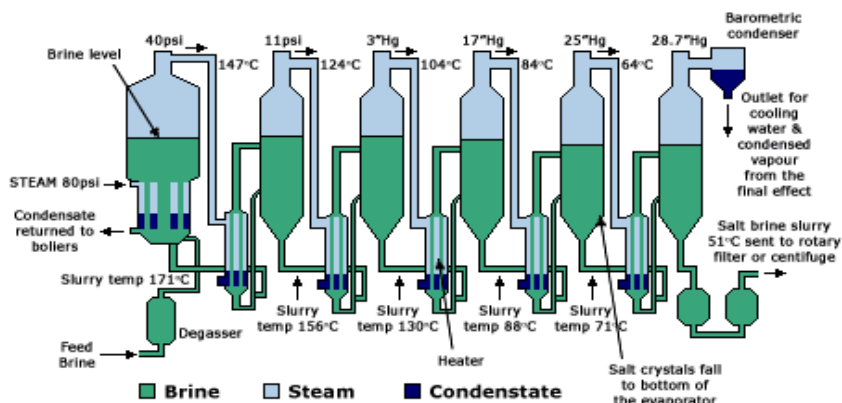


Figure-3: Salt manufacture by artificial evaporation.

The salt slurry is then conveyed to a cone shaped tank from where it passes to feed tank for dewatering and drying. The filtered and partially dried salt from the feed tank finally goes to a rotary drier for final drying. The lumps of the dried salt are removed from fine dry crystals by passing through a scalping screen. The salt is then conveyed to storage bins, where it is screened, sized and packed. Free flowing table salts are made by blending 0.5-2% magnesium carbonate (MgCO_3), hydrated calcium silicate (Ca_2SiO_4) or tricalcium phosphate [$\text{Ca}_3(\text{PO}_4)_2$] with the salt. Iodized salt after blending contains 0.01% potassium iodide (KI), 0.1% sodium carbonate (Na_2CO_3) as stabilizer and 0.1% sodium thiosulfate ($\text{Na}_2\text{S}_2\text{O}_3$).^[3]

3. Freezing Method: In some countries, salt is also manufactured by freezing the brine, but it is not a common method.



Figure-4: Salt from brine from its yellowish/off white color is bleached by chemical process-stripped of its minerals like Calcium, Magnesium by bleaching with chemical process.

CONCLUSION

Salt is obtained from two sources: rock salt and brine. Rock salt is simply crystallized salt, also known as halite. It is the result of the evaporation of ancient oceans millions of years ago. Large deposits of rock salt are found in the United States, Canada, Germany, Eastern Europe, and China. Sometimes pressure from deep inside the Earth forces up large masses of rock salt to form salt domes. In the United States, salt domes are found along the Gulf Coast of Texas and Louisiana. Brine is water containing a high concentration of salt. The most obvious source of brine is the ocean, but it can also be obtained from salty lakes such as the Dead Sea and from underground pools of salt water. Large deposits of brine are found in Austria, France, Germany, India, the United States, and the United Kingdom. Brine may also be artificially produced by dissolving mined rock salt or by pumping water into wells drilled into rock salt. Natural brines always contain other substances dissolved along with salt. The most common of these are magnesium chloride, magnesium sulfate, calcium sulfate, potassium chloride, magnesium bromide and calcium carbonate. These substances may be as commercially valuable as the salt itself. Rock salt may be quite pure, or it may contain various amounts of these substances along with rocky impurities such as shale and quartz. For table salt, however, additives are usually mixed in. Most table salt

PROPERTIES

Molecular formula: NaCl , Molecular weight: 58.44gm/mole, Appearance: White crystal, Odor: Odorless, Boiling point: 1413°C , Melting point: 801°C , Density: 2.165gm/mL, Solubility: Soluble in water.

USES

(a) In chlor-alkali industries (b) In manufacture of chemical like caustic soda and chlorine, soda ash, sodium sulfate, hydrochloric acid etc. (c) In manufacture of soap, dyes (d) Used in textile, food processing, pharmaceutical industries (e) High way ice and snow removal (f) Used in fire extinguisher (g) Used in household food preparation.^[4]

is iodized in order to provide the trace element iodine to the diet. This helps to prevent goiter, a disease of the thyroid gland. To supply iodine, a small amount of potassium iodide is added. Table salt also contains a small amount of various chemicals used to keep the salt from absorbing water and caking. These chemicals include magnesium carbonate, calcium silicate, calcium phosphate, magnesium silicate, and calcium carbonate.

Processing rock salt:

1. Underground salt deposits are usually discovered by prospectors searching for water or oil. When salt is detected, a diamond-tipped, hollow drill is used to take several regularly spaced core samples throughout the area. These samples are analyzed to determine if salt mining would be profitable.
2. When a site is selected for mining, shafts are sunk into the center of the salt deposit. Then a machine that looks like a gigantic chain saw is used to cut a slot about 6.0 inches (15 cm) high, about 66 feet (20 m) wide, and about 10 feet (3 m) deep into the salt at floor level. This process is known as undercutting. A series of holes are drilled into the undercut salt with an electric drill containing a tungsten carbide bit. These holes are filled with an explosive such as dynamite or ammonium nitrate. Electric blasting caps connected to long wires are attached, and the explosive is detonated from a safe distance. Cutting

and blasting are repeated in a pattern that leaves pillars of salt standing to support the roof of the mining area. This is known as the room-and-pillar method and is also used in coal mines.

3. Chunks of blasted rock salt are transported to an underground crushing area. Here they are passed over a grating known as a grizzly which collects pieces smaller than about 9 inches (23 cm). Larger pieces are crushed in a rotating cylinder between metal jaws with spiked teeth. The salt is then transported outside the mine to a secondary crushing area where a smaller grizzly and a smaller crusher reduce the particle size to about 3.2 inches (8 cm). At this point foreign matter is removed from the salt, a process known as picking. Metal is removed by magnets and other material by hand. Rocky material may also be removed in a Bradford breaker, a rotating metal drum with small holes in the bottom. Salt is dumped into the drum, breaks when it hits the bottom, and passes through the holes. Rocky matter is generally harder than salt, so it does not break and does not go through. The picked salt then goes to a tertiary crushing area, where an even smaller grizzly and crusher produce particles about 1.0 inch (2.5 cm) in size. If smaller particles are needed, the salt is passed through a grinder consisting of two metal cylinders rolling against each other. If purer salt is needed, rock salt is dissolved in water to form brine for further processing. Otherwise the crushed or ground salt is passed through screens to sort it by size, poured into bags, and shipped to the consumer.
4. The simplest method of evaporating brine is solar evaporation, but it can only be used in hot, dry, sunny places. The brine is collected into shallow ponds and allowed to evaporate in the sun. Insoluble impurities such as sand and clay and slightly soluble impurities such as calcium carbonate settle to the bottom as evaporation begins. The brine is pumped or moved by gravity flow to another pond where calcium sulfate settles out as evaporation continues. The remaining brine is moved to yet another pond where the salt settles out as evaporation proceeds. The brine is moved one more time before evaporation is complete to prevent highly soluble impurities such as magnesium chloride, magnesium sulfate, potassium chloride, and magnesium bromide from settling out with the salt. These substances may be collected separately for commercial use.
5. The salt is scooped up by machines running on temporary railroad tracks laid on top of the layer of salt. It is then washed with highly concentrated salt water. This water contains so much salt that it cannot hold any more, so the salt is washed free of any trace impurities without dissolving. The washed salt is removed from the salt water, rinsed with a small amount of fresh water, and piled into huge stacks to drain for two or three months. At this point the salt is about 99.4% pure and can be used for many industrial purposes. If purer salt is needed, it is rewashed in salt water and fresh water, allowed to drain for one or two days and then dried in a hot air oven at about 365°F (185°C). This salt is about 99.8% pure and can be used for food processing.
6. Most brine is processed by a multiple-effect vacuum evaporator. This device consists of three or more closed metal cylinders with conical bottoms. Brine is first treated chemically to remove calcium and magnesium compounds. It then fills the bottom of the cylinders. The brine in the first cylinder passes through tubes heated by steam. The brine boils and its steam enters the next cylinder, where it heats the brine there. The steam from this brine heats the brine in the next cylinder, and so on. In each cylinder the condensation of steam causes the pressure inside to drop, allowing the brine to boil at a lower temperature. Salt is removed from the bottom of the cylinders as thick slurry. It is filtered to remove excess brine, dried, and passed through screens to sort the particles by size. Salt made this way is known as vacuum pan salt and consists of small cubic crystals.
7. Brine may also be processed in a grainer. The brine is chemically purified and pumped into a long open pan heated by steam running through pipes immersed in the brine. The brine is heated to a temperature slightly below the boiling point and flakes of salt form on its surface as it evaporates. Usually a temperature of about 194°F (90°C) is used. Lower temperatures produce larger flakes and higher temperatures produce smaller flakes. The flakes grow until they sink to the bottom of the pan, where they are collected and dried. Grainer salt consists of small flakes rather than cubes and is preferred for certain uses in food processing. Sometimes the Alberger process is used, in which the brine is first partially evaporated in a vacuum evaporator then moved to a grainer. This process produces a mixture of flakes and cubes.
8. At this point salt used for most purposes is ready to be packaged in bags or boxes and shipped to consumers. To make iodized table salt, however, potassium iodide is added and then magnesium carbonate, calcium silicate, calcium phosphate, magnesium silicate, or calcium carbonate is added to make it free-flowing. The salt is then packaged and shipped to restaurants and grocery stores.

Quality Control: Specifications for salt vary widely according to the intended use. Salt intended for human consumption must be much purer than salt used for melting snow and ice, but salt used for certain scientific purposes may need to be even purer. For most purposes, rock salt is allowed to have a gray, pink, or brown tinge rather than being pure white. The impurities that cause these colors may make up as much as 4% of a test sample. To test solubility, a 0.7-ounce (20 g) sample is placed in 6.8 fluid ounces (200 ml) of water. It should completely dissolve in no more than 20 minutes. Evaporated salt intended for food processing is very pure, containing as much as 99.99% sodium chloride

before additives are mixed in. This is important not only for safety and good taste, but because certain impurities can cause problems with certain foods. For example, small amounts of calcium tend to toughen vegetables. Traces of copper or iron tend to destroy vitamin C and to increase the rate at which fatty foods become rancid. In addition, calcium and magnesium both tend to make salt absorb more water, causing it to cake.

Health Aspects: Salt intake—or more precisely, sodium intake—is a controversial topic in health care today. Healthy adults can safely consume 0.2-0.4 ounces (6-11 g) of salt daily, which is equivalent to 0.08-0.14 ounces (2400-4400 mg) of sodium. For some people with high blood pressure, salt intake should be reduced. About one-third to one-half of all hypertensive people are salt-sensitive and will benefit from a low-sodium diet. Since there is no way to tell who these people are, most hypertensives under medical care will be placed on such a diet to see if it helps. A low-sodium diet usually aims to reduce sodium intake to less than 0.08 ounces (2400 mg) per day. While some have suggested that everyone should reduce salt intake, others point out that there is no evidence that salt restriction is of any benefit to otherwise healthy individuals.

REFERENCES

1. Apurbo Sarker, Arittra Ghosh, Kinsuk Sarker, Debojyoti Basu and Prof. Dr. Dhruvo Jyoti Sen; *Halite; the rock salt: enormous health benefits*: World Journal of Pharmaceutical Research, 2016; 5(12): 407-416.
2. Debojyoti Basu, Divyesh Sharma, Vipul Darji, Honey Barot, Jyoti Patel, Dinkal Modi and Prof. Dr. Dhruvo Jyoti Sen; *Discard biochemical malfunction by black salt through naturopathy*: European Journal of Pharmaceutical and Medical Research, 2015; 2(6): 96-101.
3. Lück Erich, von Rymon Lipinski, Gert-Wolfhard. Foods and Food Additives. *Ullmann's Encyclopedia of Industrial Chemistry*, 2000.
4. Lipasek R. A., Taylor L. S and Mauer L. J. *Effects of anti-caking agents and relative humidity on the physical and chemical stability of powdered vitamin C*. Journal of Food Science, 2011; 76(7): C1062–74.