

A comparative assessment of Goan natural solar salt and its adequacy in iodine content and nutritive value

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Abstract

Salt production has been a traditional occupation in Goa. Goa has been exporting salt to several African and Arabian countries during the post-medieval period and presently, has only sixteen active salterns. This salt is consumed as well as used for various commercial purposes by the local Goan population. However, today a myth exists that our natural salt is devoid of iodine. Hence a majority of the local communities of Goa are now shifting from their centuries old practice of using natural salt to refined salt available in the markets. Therefore, in order to probe the contentions of this myth we have sampled salt from five solar salterns in different localities of North of Goa viz. Ribandar, Batim in Tiswadi; Agarwaddo in Pernem, Nerul and Arpora in Bardez taluka for a comparative study of iodine and bacterial load. SEM-EDS studies on salt quality show the presence of various trace elements. The iodine content and the stability of natural salt is comparable to the commercial brands of refined salts available in the market. Most importantly, bacterial pathogens have been below detectable limits. We, therefore, infer that salts produced from the solar salterns of Goa, besides including various micronutrients is sufficient in iodine content. Of all the samples studied, Arpora salt is comparatively of the best quality.

Keywords

*Salt quality
Iodine
Natural salt
Nutrients
Minerals*

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Introduction

Salterns are extremely halophilic artificial environments consisting of discontinuous salinity gradients, ranging from 10 to 350 psu (Kerkar and Bharathi, 2011), which are commercially operated for producing salt by allowing the seawater to evaporate. Salt production has been a traditional occupation in Goa since antiquity. The traditional salterns of Goa are inundated by tidal waters and monsoon run-off, for the extraction of salt. Some of these are located in Ambelim and Agarwaddo in Pernem taluka, Nerul and Arpora in Bardez taluka, Ribandar, Batim, and Siridao in Tiswadi taluka and Cavellosim, Mobor in Salcete taluka. For centuries, they had been providing adequate salt for the needs of the local populace, whether for consumption or commercial use. However, this salt production received a set back after liberation due to breaching of bunds, land reclamation and water pollution caused due to industries and tourism (Prabhudesai, 1997).

Refined salt is normally white, whereas natural salt has a greyish/ reddish tinge. Refined salt is supplemented with sodium chloride and additives like aluminium silicate for a powdery and porous consistency. However, aluminium could be toxic to the nervous system (Bondy, 2010). Iodization of

refined salt is a common, long term and alternative solution that could continue to be used to ensure that iodine reaches the entire population and is ingested on a regular basis.

Iodine is an essential element needed for the synthesis of two major hormones, namely, thyroxine and tri-iodothyromine that are produced in the thyroid gland and play an important role in metabolism, the deficiency of which can lead to goiter and cretinism (Nutrition Foundation of India, 1983). Potassium iodate and potassium iodide are normally used as iodine supplements in refined salt. Natural salt is a source of twenty one essential elements and thirty accessory minerals that are essential for health (Bergner, 1997). Thus, natural sea salt contains essential minerals but refined amended sea salt contains mainly sodium and chloride. Natural salt has, therefore been found to be a better condiment as compared to refined salt.

WHO recommends 150 µg or more of iodine as a daily requirement for adults (WHO, UNICEF, ICCIDD, 1996). Iodine deficiency has been the cause of world's preventable mental retardation. Its severity can vary from mild intellectual set back to intense cretinism, and various other defects. In addition to mental retardation, goitre is an important consequence of iodine deficiency. Unlike nutrients such as iron,

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calcium or vitamins, iodine does not occur naturally in specific foods; rather, it is present in the soil and atmosphere and is ingested through foods (Johanson, 2000). Seawater is an important reservoir of iodine (Fuge, 1996), thus people dwelling in coastal areas and consuming sea fish and kelp are more likely to be iodine sufficient. However, these resources are not accessible to everyone and if accessible, may or may not be consumed by personal choice.

Developed countries use both potassium iodide (KI) and potassium iodate (KIO_3) extensively for iodization of refined table salt. However, KI in salt is not very stable and gets oxidized to iodine with moisture, humidity or arid environments, sunlight, heat and presence of impurities in the salt. Iodate is more stable under adverse climatic conditions than iodide and does not require stabilizers. Most people in iodine deficient areas use unrefined salt that can be effectively supplemented with KIO_3 . However, KI contains higher percentage of iodine (76.5%) as compared to KIO_3 which contains 59.5%.

The monopoly of salt industries and advertisements on the fortification of natural salt has engendered a misconception leading to a delusional perception that all natural salts are devoid of iodine. This faulty belief has successfully directed the society also in Goa, as elsewhere towards the consumption of refined salt, which, consequently, has had a great impact in the steady eradication of the traditional and more economic salt produced by salterns of Goa. This verity has driven this present study and found it important to assess the quality of natural salt. The main purpose of this study is to correct the notion that natural salt is of low quality and devoid of iodine.

Materials and Methods

Site description

Goa has around 200 salterns in 13 villages of Pernem, Bardez, Tiswadi and Salcete talukas of which around sixteen salterns are active. Five sampling sites were selected from North Goa. Salt samples were collected from the salterns of Agarwaddo, Arpora, Nerul, Ribandar and Batim during the pre-monsoon season, in the month of February, 2012.

Sample collection

Salt and water samples were collected from the five sampling sites. The salt samples were collected in sterile PVC bags and water samples were collected in sterile bottles. These samples were immediately stored for further physico-chemical and microbiological analysis.

Analysis of nutrients and minerals in natural salt

Salt samples (100 g) from five different salterns were individually weighed and dissolved in 100 mL of MilliQ water, stirred and filtered using Watman filter paper 1. The filtrate was evaporated and immediately placed in a desiccator. The respective samples were placed on a nylon stub with a carbon conductive tape. The specimen was then sputter coated (20 nm) with gold. The coated sample was analysed by SEM (model JEOLJSM5800LV) with an Oxford EDS attachment.

Estimation of trace elements by AAS

The salt samples were analyzed for zinc, iron, manganese, copper and nickel by Varian Flame AAS (AA240FS Fast sequential atomic absorption spectrophotometer, USA.). The 1000 ppm standard solutions of the metals were diluted in different concentration for quantitative analysis. All the measurements for samples and standard solutions were carried out in triplicates.

Estimation of iodine content of salt

The iodine content of the five natural salt samples collected was quantified using an iodometric titration, as described by DeMaeyer *et al.* (1979). Iodine content of saltern water from the five salterns sampled was estimated using colorimetric method (Agrawal, 1999).

Stability of natural and refined salt

The stability of natural and refined salt was assessed on storage and boiling to evaluate the shelf life of the iodine content in the salt.

Measurement of iodine content of salt after boiling

Salt sample of natural and refined salt (10 g each) were weighed and dissolved in 30 mL of milliQ water in a stoppered Erlenmeyer flask and the volume was adjusted to 50 mL. The solution was heated to boiling, cooled and titrated against 0.005M sodium thiosulphate as described above by iodometric titration (DeMaeyer *et al.*, 1979).

Periodic testing of the stability of iodine

Two samples were chosen randomly from the refined salt and three samples from natural salt for periodic iodine stability test. Salt sample of natural and refined salt (10 g each) were weighed and kept exposed in a Petri plate at room temperature. Titration was carried out using 0.005M sodium thiosulphate by iodometric titration method (DeMaeyer *et al.*, 1979) after a period of 1, 5, 15, 30 and 45 days at 28 ± 2 °C.

Microbiological parameters of natural salt

Heterotrophic count

The salt samples from the five respective salterns were serially diluted in sterile saltern water and plated on modified salt agar (20% w/v natural salt in Nutrient agar) and incubated at 38°C for 15 days (Rodriguez-Valera, 1981) and on Potato dextrose agar (PDA). The heterotrophic counts were enumerated as CFU/g.

Enteric pathogens

Salt samples were serially diluted with sterile saltern water and plated on MacConkey's agar, Eosine methylene blue (EMB) agar, TCBS agar and Salmonella Shigella agar. All the plates were incubated at 37°C. MacConkey's agar and EMB agar plates were incubated for 24 hrs while Salmonella-Shigella agar and TCBS agar plates for 3 days. Colony forming units were enumerated after their respective incubation periods. All media used were from Hi-Media.

Result

The natural salt collected from the five salterns of Goa were assessed for various parameters. The salt samples contained seventeen elements including sodium and chloride confirmed by SEM-EDS studies and AAS (Table 1 and 2). The iodine content of natural salt and refined salt samples were measured by quantitative titration analysis and compared as shown in Figure 1. Among refined salt, Saffola salt showed the highest concentration of iodine, followed by Captain Cook, Tata and Kirtal Kothari salt. Iodine content in natural salt was comparatively low; however significant amount was estimated in natural salts from Ribandar, Arpora, Batim and Nerul. Agarwaddo salt, was white in colour as compared to the other salts analyzed, has the least amount of iodine. The stability profile of iodine with boiling and exposure to room temperature over a period of 45 days is shown in Table 3 and Figure 2. A marked decrease in iodine was observed in both refined and natural salt on boiling as well as on exposing it to room temperature during the period.

Heterotrophic bacteria were encountered on modified salt agar from salt samples of Nerul. Bacterial colonies were also detected on PDA from Ribandar and Batim salt samples (Table 4). No enteric pathogens were detected in the salt samples except from the Ribandar salt samples, where *Enterobacter* spp. was found at an average level 20×10^5 cfu/g on EMB agar.

Table 1. Elements present in Goan natural salt by SEM-EDS method

Element in weight %	Sampling Site				
	Agarwaddo	Arpora	Batim	Nerul	Ribandar
Oxygen	25.17	13.22	5.73	18.51	21.14
Sodium	24.12	30.86	2.79	27.79	26.18
Magnesium	4.45	1.65	0.49	3.33	3.67
	0.69	-	0.17	-	-
Chlorine	42.39	52.34	5.85	46.68	46.1
Potassium	0.74	0.18	0.06	0.25	0.59
Bromine	0.34	-	-	0.19	0.25
Molybdenum	2.11	1.44	-	3.00	1.97
Boron	-	-	84.87	-	-
Silicon	-	-	0.03	-	-
Calcium	-	0.14	0.03	0.25	0.10
Aluminium	-	0.17	-	-	-

- Not detected

Table 2. Elements present in Goan natural salt by AAS (ppm)

	Zinc	Nickle	Iron	Copper	Manganese
Agarwaddo	0.060	0.060	3.318	0.059	0.036
Arpora	0.670	0.093	8.66	0.014	0.094
Batim	0.057	0.097	11.25	0.112	0.122
Nerul	0.063	0.11	16.04	0.064	0.174
Ribandar	0.032	0.065	22.58	0.012	0.245

Table 3. Comparative account of percentage decrease of iodine from refined and Goan natural salt on atmospheric exposure for 45 days and on boiling (%)

Parameters	Refined Salt		Natural Salt		
	Saffola	Tata	Arpora	Nerul	Ribandar
5 Day	6.9	30.9	11.9	28.4	41.9
10 Day	11.1	40.1	14.4	35.2	45.0
15 Day	18.0	44.0	27.8	38.7	48.3
30 Day	52.2	53.2	43.9	48.7	61.2
45 Day	61.8	65.5	59.6	55.5	67.9
After Boiling	13.9	8.5	5.8	22.6	25.4

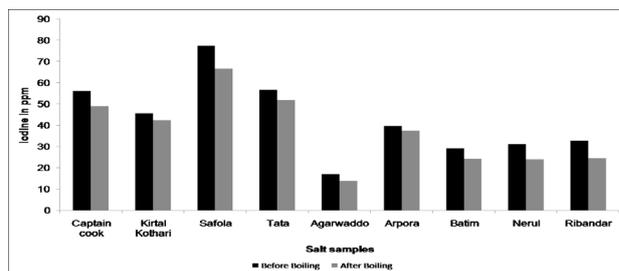


Figure 1. Comparative study of iodine content of refined and Goan natural salt before and after boiling

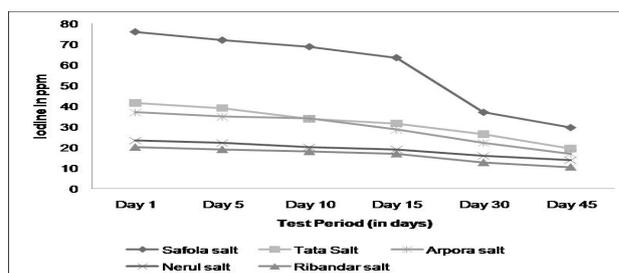


Figure 2. Comparative study of iodine content (ppm) of refined and Goan natural salt on exposure to air over a period of 45 days

Discussion

Commercial salt is highly refined sodium chloride. Other elements that occur in natural sea salt are usually eliminated during processing. Most of the natural salts in Goa has around 17 minerals including sodium and chloride which are vital for the human body.

Table 4. Bacterial counts of Goan natural salts (cfu/g)

Saltern	Heterotrophic Count (cfu/g)	
	Mod. salt agar	PDA
Agarwaddo	nd	nd
Arpora	nd	nd
Batim	nd	0.1 x 10 ⁴
Nerul	14.8 x 10 ⁶	nd
Ribandar	nd	30.55 x 10 ⁴

nd = not detected.

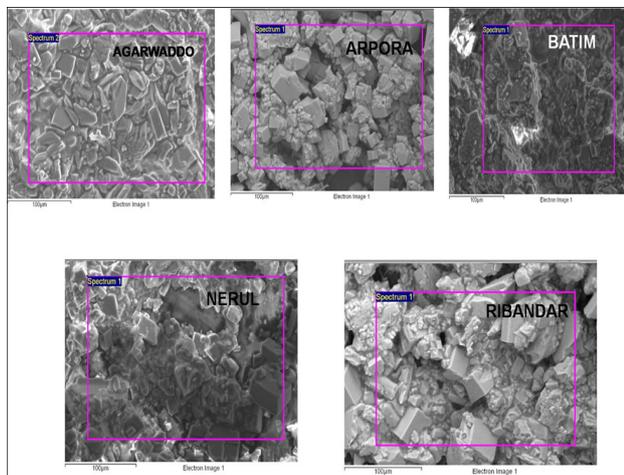


Figure 3. SEM-EDS micrograph depicting the morphological variation of natural salt crystals from five salterns of Goa

Iodine exists in the form of iodine ions in the sea (Fuge, 1996), seaweeds (Teas *et al.*, 2004), subsurface brines and mineral waters (Fuge and Johnson, 1986). Subsequent to the pioneering work of the French scientist Boussingault, in Columbia in 1831, dealing with the use of natural iodized water and/or salt to prevent goiter, iodine has been used for the treatment of goiter. Iodine has been found in other foods besides salt. Japan is one of the few countries where salt is not iodized because the Japanese diet contains large amounts of iodine rich seaweed (Martinelango *et al.*, 2006). Iodine is also present in the seaweeds in Goa (Solimabi, 1977), in seafood (Harrison *et al.*, 1965) and unrefined salt that are the source of salt for the coastal inhabitants. Since August 15th 1977, the Government of Goa has banned the sale of non-iodized salt for human consumption as per the guidelines issued by International Council for Control of Iodine Deficiency Disorder, courtesy WHO & UNICEF.

The recommended level of iodine intake per day is 150 µg/day of iodine (WHO, UNICEF, ICCIDD, 1996). In order to provide this level of iodine WHO/UNICEF/ICCIDD recommends that iodine concentration should be within the range of 20-40 mg of iodine (or 36-66 mg potassium iodate) per kg of salt (WHO, UNICEF, ICCIDD, 1996). The majority of the natural salts produced in Goa were found to have 16.9 to 39.6 ppm of iodine, which is within the recommended levels by WHO/UNICEF/ICCIDD. We

have expressed iodine content in the form of iodine and not in iodate or iodide forms to avoid confusion since the chemical form is not clearly identified. The concentrations obtained, imply that most of the natural salt in Goa has a substantial concentrations of iodine.

Since, iodine is a volatile compound, it gets easily depleted from salt on exposure to heat. The loss of iodine from the production site to household has been estimated to be 20% (WHO, UNICEF, ICCIDD, 1996). Another 20% is lost during cooking (WHO, UNICEF, ICCIDD, 1996). In addition, Rana and Raghuvanshi (2011) found that iodine loss depends upon the type of cooking method which ranged from 6.58% to 51.08% and the time of addition of salt during cooking. In the present work we chose to determine iodine loss upon boiling a 20% natural salt solution. The loss of iodine subsequent to boiling for 5 minutes was in a range of 5.8 – 25.31%. Iodine losses have been reported by Zigong Institute (1992) when refined salt packed in open 1 kg plastic film bags, heated to 130°C for 2.5 hr. to simulate drying, and stored at ambient temperature were found to be 5.7% after 12 months and 11% after 3 years. The iodine loss after 45 days was ca. 61% and ca. 64% in natural salt and refined salt respectively. Our studies thus suggest that the stability of iodine in natural sea salt is greater than in refined salt (Figure 2). We also have observed that each salt crystal from different localities differ in its morphology (Figure 3).

The major effect of salt on microorganisms is plasmolysis due to hypotonic tension. However, some microorganisms, like halotolerant and halophilic bacteria have the ability to cope up with the high salt concentration. Thus, salt would normally harbour less microbial diversity. However, heterotrophic bacterial counts obtained with Nerul salt suggest the presence of halotolerant bacteria. Bacteria were also encountered on potato dextrose agar from Ribandar and Batim salt, indicating that these bacteria could be acidotolerant species. Due to high temperatures and high salinity, salt normally inhibits the growth of most microorganisms including pathogens. Analysis for enteric pathogens revealed that natural salt were free from pathogens. However, Ribandar salt showed the presence of non-pathogenic *Enterobacter* sp. with no detectable levels of *E. coli*. We thus conclude that this locally manufactured natural salt is safe for human consumption even without any further processing.

Conclusion

In Goa, sixteen solar salterns still exist while the traditional profession and the activity of

manufacturing salt is declining. The present study was carried out to prove that the iodine content prevalent in the local salts is substantial and is on par with the refined salt available in the market. Our study establishes that though the iodine content in natural salts is lower than refined salts, it is still within acceptable limits for human consumption. Hence to conclude, we can say that the myth of natural salt lacking iodine is not true. Natural salt can thus supplement our required iodine satisfactorily in the diet and also complement the nutritive value since Goan natural salt has around 17 minerals which are vital for the human body.

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