Asia Pacific J Clin Nutr (1997) 6(2): 92-94

Dry mixing technique for the large scale production of iodine fortified salt in India

S Ranganathan[1], S Sundaresan[2], I Raghavendra[3] and S Kalyani[3]

[1]*National Institute of Nutrition, Indian Council of Medical Research, Hyderabad,* [2]*Salt Department, Government of India, Jaipur,* [3]*Department of Industries and Commerce, Government of Tamilnadu, Madras*

Dry mixing technique was used successfully in three factories in India for the manufacture of iodine fortified salt. Permitted food additives, calcium carbonate and magnesium carbonate, were used with potassium iodate. The technology was smooth and free from any problem. Since the formerly conventional, but now superceded on analytical performance criteria, spray-mixing system was not used in the study, plants of the economics either batch mixing or continuous processes were more in evidence, and could be compared with avoidable spray mixing production performance data. The iodine fortified salt was free-flowing and retained the colour of the common salt. The iodine distribution was uniform (about 30 ppm). Long distance road transportation did not affect the iodine stability and its consistency. Storage studies showed satisfactory stability and the fortified salt had prolonged shelf-life beyond one year.

Key words: Iodine fortified salt, potassium iodate, calcium carbonate, dry mixing, free-flowing, stability, shelf-life, India, Tuticorin, Machilipatnam, Hyderabad

Introduction

Iodine deficiency disorders (IDD) constitute a major public health problem in India which afflicts millions of people. Available evidence reveals that no state in the country is free from IDD and population studies, whenever undertaken, are continuously exposing new pockets of iodine deficiency[1]. It is estimated that nearly 167 million people are suffering from IDD of which 54 million have goitre. 2.2 million are cretins and 0.6 million have mild neurological problems[2]. Fortification of common salt with iodine is a long term and sustainable low cost approach to control IDD as this will enable the population to ingest daily the required amount of iodine[3]. The reasons are clear: salt is one of the few food items which is consumed universally irrespective of socio-economic status, salt fortification with an iodine compound is a simple mixing operation without any chemical reaction, the colour, taste or flavour of the fortified salt are the same as that of the common salt, and it is acceptable to all since no change is observed in the organoleptic properties of foods prepared from iodine fortified salt.

The technology of salt fortification with iodine is well established in India. The usefulness of the dry mixing technique, when compared to conventional spray mixing, in increasing the stability and shelf-life of iodine fortified salt has been clearly demonstrated by laboratory studies in India[4]. However, information on the large scale production of iodine fortified salt by dry mixing technique in India is scanty. It was recommended in the "Motivation Campaign on IDD control through Salt Iodation", to explore the possibility of a pilot plant and also the feasibility of converting the existing spray mixing plants to dry mixing plants with minimum financial liability[5]. Therefore, studies were undertaken in three factories in India to manufacture iodine fortified salt by the dry mixing technique.

Methods

Studies were conducted in three factories in India. They were: M/s. Sahayamatha Salterns (P) Ltd, Tuticorin (Factory A). M/s. Laahar Salt and Chemical Works (P) Ltd, Machilipatnam (Factory B) and M/s. Jaybharathi Salts (P) Ltd, Hyderabad (Factory C).

Factory A

Edible grade solar crystal salt from Tuticorin was powdered and used. Food grade potassium iodate (KIO_3), dissolved in a minimum volume of water, was mixed with powder salt in a 100 kg stainless steel ribbon blender. After thorough mixing for ten minutes, the salt iodate-mix was dried. This had a KIO_3 equivalent to 6000 ppm iodine. Iodine fortified salt was prepared by dry mixing, for five minutes, the required quantity of the salt-iodate mix and powder salt in a 250 kg stainless steel ribbon blender. Light basic magnesium carbonate (0.3%) was added as a stabiliser/ anticaking agent. After completing the fortification, the iodine fortified salts from different regions were tested by the field kit[6] for iodine content and uniformity on the spot. Representative samples were tested by the titrimetric method[7] in the laboratory of the factory. Samples were also drawn for testing at the Salt Department laboratory, Government of India, Tuitcorin, India; Tamil Nadu State Government Laboratory, Madras, India; and the National Institute of Nutrition (NIN), Indian Council of Medical Research, Hyderabad, India. Trials were also done in the same manner using crystal salt and salt-iodate mix to produce iodine fortified crystal salt.

In order to study the effect of transportation on the stability and distribution of iodine in the fortified salt, samples were sent in a 50 kg high density polyethylene (HDPE) oven sac by road transport to the NIN where the iodine content was tested by the titrimetric method[7]. Also, the stability and shelf-life of the iodine fortified salt, when stored at ambient temperatures, were studied every month for one year.

Factory B

Batch mixing process: Edible grade crystal salt from Tuticorin was crushed and used. One part of food grade potassium iodate was mixed well with ten parts of food grade calcium carbonate and the mix was added to 500 kg crushed salt taken in the ribbon blender in which the spraying system was disconnected and not used. The level of iodation was 30 ppm. After thorough mixing for ten minutes, the fortified salt from different regions were tested for iodine content on the spot and also by the titrimetric method as in Factory A.

Correspondence address: S Ranganathan, National Institute of Nutrition, Indian Council of Medical Research, Hyderabad 500 007, India. Telex: 0425-7022; Fax: +91-40-7019074
Email: icmrnin@ren.nic.in

Continuous process: The spray mixing plant (similar to the Sambhar model) which had been used for salt iodation in the factory was available for the dry mixing technique. The roller crusher, belt conveyor and the worm-screw mixer were put into use and the spraying unit was not used. In the dry mixing technique, 25 kg crystal salt was loaded into the roller crusher followed by the addition of iodate-carbonate mix (potassium iodate 1.25g and calcium carbonate 12.5g) to give an iodine content of 30 ppm. Then another 25 kg of salt and iodate-carbonate mix were added and the same addition cycle was repeated continuously. After crushing, salt and iodate-carbonate mix passed through the conveyor belt and fell into the worm-screw mixer for final mixing. At the end, iodine fortified salt was collected in bags. The iodine content, its distribution, spot test, titrimetric estimation, the effect of transportation and the storage/ stability studies at ambient temperatures were performed as described in Factory A.

Factory C

Dry mixing technique was followed using edible grade crystal salt obtained from Tuticorin in the same manner as described for batch mixing process in Factories A and B. The only difference was the use of 100 kg ribbon blender with a mixing time of 5 minutes. All the test parameters described in Factory A were done here also.

Results

Factory A: The dry mixing technique was smooth and free from any problem. The iodine fortified salt retained the colour of common salt. The pH of a 5% aqueous solution of the fortified salt was 9.5 and the salt was free-flowing. When samples were tested for iodine content in different laboratories, the results obtained were same (Table 1). The field kit showed an iodine level of 35-40 ppm and it was uniform. In the titrimetric method, the powder salt showed a uniform iodine level of 36 ppm and the crystal salt had 40 ppm. Road transportation, covering a distance of about 1500 km, from Tuticorin to Hyderabad did not alter the consistency and stability of the fortified salt (Table 2). There was no loss of iodine even after one year of storage at ambient temperatures (Table 3). The production rate per hour by the dry mixing technique was 3 tons which was the same quantity normally produced by the spray mixing technique in this factory.

Table 1. Iodine content of iodine fortified salt produced by dry mixing technique in Factory A.

Iodine fortified salt type	Iodine content (ppm) NIN*	Salt Dept**	State Lab***
Powder salt:			
Sample 1	36	36	34
Sample 2	36	37	–
Sample 3	6	36	18
Crystal salt:			
Sample 1	40	41	–
Sample 2	41	39	–
Sample 3	40	43	–

* National Institute of Nutrition, Indian Council of Medical Research, Hyderabad, India.
** Office of Assistant Salt Commissioner, Govt of India, Tuticorin, India.
*** Chemical Testing and Analytical Laboratory, Tamil Nadu State Govt, Guindy, Madras, India (Only sample 1, powder salt was tested).

Table 2. Effect of transportation on iodine stability of iodine fortified salt produced by dry mixing technique in the Factory A.

Iodine fortified salt type		Iodine content (ppm) Initial	After transportation*
Powder salt:	Top layer	36	36
	Middle layer	36	36
	Bottom layer	36	36
Crystal salt:	Top layer	40	41
	Middle layer	40	40
	Bottom layer	40	41

* Transported in 50 kg bags from Tuticorin to Hyderabad, India.

Factories B and C: The iodine fortified salt was free flowing and had a bright white colour as compared to the unfortified salt. Spot tests showed an iodine level of 30 ppm and the titrimetric method also showed the same iodine level. The iodine distribution was uniform (30 ppm). Transportation by road from Machilipatnam to Hyderabad did not affect the stability and distribution of iodine in the fortified salt. The initial iodine level of 30 ppm was retained even after one year of storage (Table 4). The top, middle and bottom layers of the fortified salt in the 50 kg bags showed the same iodine concentration. The iodine content, uniformity and stability of the fortified salt remained the same in both batch mixing and continuous process in the Factory B. The pH of a 5% aqueous solution of the fortified salt was 9.1 in the two factories. The production was smooth and no problem was observed. The observed daily production rate by the dry mixing technique was the same as with the spray mixing technique in these two factories.

Table 3. Stability and shelf-life of iodine fortified salt produced by dry mixing technique in the Factory A.

Iodine fortified salt type	Iodine content (ppm)* Initial	3 mo	6 mo	9 mo	12 mo
Powder salt:					
Top layer	36.0	35.9	35.8	36.1	36.1
Middle layer	36.0	36.1	36.0	35.9	36.0
Bottom layer	36.0	35.8	35.9	35.8	36.1
Crystal salt:					
Top layer	40.0	41.0	41.1	41.2	41.0
Middle layer	40.0	40.0	40.3	40.2	40.1
Bottom layer	40.0	41.0	41.0	41.1	41.1

* Stored in 50 kg bags at ambient temperatures.

Table 4. Stability and shelf-life of iodine fortified salt produced by dry mixing technique in the Factories B and C.

Factory	Iodine content (ppm)*				
Factory B	**Initial**	**3 mo**	**6 mo**	**9 mo**	**12 mo**
(i) Batch mixing					
Top layer	30.0	29.9	30.1	30.0	30.0
Middle layer	30.1	30.0	30.2	30.2	30.1
Bottom layer	29.9	30.0	29.8	29.9	29.8
(ii) Continuous					
Top layer	30.0	29.8	29.8	30.1	30.1
Middle layer	30.0	29.8	29.7	30.0	30.0
Bottom layer	30.0	29.7	29.8	30.2	30.1
Factory C					
Top layer	30.0	30.1	29.9	30.2	30.1
Middle layer	30.0	30.1	30.2	30.1	30.0
Bottom layer	30.1	30.1	30.0	29.9	30.0

* Stored in 50 kg bags at ambient temperatures.

Discussion

In the fortification of common salt with iodine, the object is to add a predetermined, very small proportion of an iodine compound in such a way that it is uniformly and effectively mixed with a very much greater bulk of material (salt) to produce a homogenous mixture which is preferably non-caking and in any case, capable of withstanding any tendency for the constituents to segregate. Essentially, there are three techniques to achieve this objective: spray mixing, dry mixing and submersion processes. Continuous large-scale spraying techniques generally involve conveyor mechanisms and, as a rule, are designed to treat fine, free-flowing salt. Dry mixing methods provide for the addition of non-caking and stabilising compounds in addition to the iodine compounds. The submersion process depends mainly on the natural environment as it is an open field technique and has associated quality problems.

In a tropical country like India, addition of water to dissolve the iodine compound in the spray mixing technique, ultimately increases the moisture of the fortified salt by an extra 2-3% which in turn plays a detrimental role on the stability of iodine and the shelf-life of the iodine fortified salt. In an earlier study, it was observed that the iodine loss ranged from 25 to 30% in the first 3 months after fortification although KIO_3 was used as the source of iodine[8]. The justification of fixing an iodine level of not less than 30 ppm at the production level is to allow for loss of iodine so a minimal level for the consumer of 15 ppm would be available.

In addition to problems due to extra moisture, the spray mixing technique requires a reservoir for iodate solution, a pump and an air blower to spray the solution. A dryer is also needed to remove the extra moisture from the fortified salt whenever necessary. Thus, the cost of the production increases in the spray mixing technique due to the additional inputs in the form of extra machinery, electricity and higher level of iodation, as compared to the dry mixing technique where the spraying system is not used. These are the drawbacks observed in the spray mixing technique. What is actually needed is an inexpensive and comparatively simple method which can ensure uniform distribution of iodine and satisfactory stability of iodine in the fortified salt. The present study shows that all these factors are achievable with the dry mixing technique in these factories. The usefulness of the dry mixing technique for salt fortification with other nutrients, such as iron, has been demonstrated in India[9,10]. The present study confirms these observations.

Most of the salt produced in India is crystalline salt obtained by heated open-pan or solar evaporation of brines. A simple process by which crystalline salt can be crushed and easily mixed with a stock mixture of KIO_3 and calcium carbonate (or magnesium carbonate) to produce iodine fortified salt is ideal for the country. Since the amount of carbonate added is considerably greater than the quantity of potassium iodate, this process ensures homogeneity and results in a very satisfactory uniformity of iodate distribution in the fortified salt. An important advantage of KIO_3 is its low solubility in water compared with the high solubility of potassium iodide (KI). If a package of salt fortified with KI becomes damp, the iodide is attracted to the areas of high moisture content and then migrates from the body of the salt to the fabric of the container. This results in a loss of iodide from the mass of the salt with a consequent reduction of its iodine content. Because of the low solubility, KIO_3 migrates much less readily. Furthermore, the addition of carbonate prevents this migration and hence enhances the stability and shelf-life of the fortified salt. This benefit was observed in the present study as there was no difference in the iodine content of the top, middle, and bottom layers of the fortified salt after transportation (Table 2) nor during storage (Tables 3 and 4). This observation is also in agreement with others[11]. Calcium carbonate has been found useful as an iodised salt conditioner in the factory for the iodine fortification of crystalline salt by dry mixing technique abroad[12].

It can be seen, that in all three factories, the dry mixing technique was successful, smooth, and economical for the large scale production of iodine fortified salt of uniform iodine distribution and long shelf-life. The method is patently less expensive when the spraying system is not required in existing plants for batch mixing or continuous processes. The carbonates used in the study are inexpensive (about one paise per kg of salt) and their cost in the fortified salt is offset by a reduction in the initial level of iodine to 20 ppm instead of 30 ppm, and the expenditure on the import of iodine can be minimised. Iodine fortification salt factories in India can readily convert from the existing spray mixing plants to the dry mixing technique without any additional cost and can continue to maintain the same daily production rate of fortified salt.

The work done in M/s Sahayamatha Salterns (P) Ltd, Tuticorin, India is based on a study by the committee of which the authors were the members constituted by the Salt Commissioner, Government of India, to examine the technical feasibility of iodation of salt by the dry mixing technique in India.

Acknowledgments. The interest shown and the encouragement given by Dr Vinodini Reddy, Director, NIN and Shri R Prakash, Salt Commissioner, Government of India in this study are gracefully acknowledged. The authors are extremely thankful to the owners of the factories for their unstinted cooperation in the study. Thanks are also due to Mrs Swayamprabha for her excellent secretarial assistance.

Dry mixing technique for the large scale production of iodine fortified salt in India

S Ranganathan , S Sundaresan, I Raghavendra and S Kalyani

Asia Pacific Journal of Clinical Nutrition (1997) Volume 6, Number 2: 92-94

大量生產強化碘鹽的乾混合方法

摘要

印度有三間工廠成功地用乾混合方法製造強化碘鹽。他們以許可的食物添加劑、碳酸鈣、碳酸鎂和碘酸鉀混合，該方法是順利的，同時沒有任何問題。不管是一次混合或連續加工，自從噴霧系統沒有在現存的工廠應用以後，該法是經濟的。強化碘鹽是固體狀態並保存普通食鹽的顏色。碘分佈是均勻的（約 30 ppm）。長距離運輸不影響碘的穩定和濃度，貯存研究顯示穩定性滿意，強化碘鹽的貯存壽命可超過一年。

References

1. Status Report on the National Iodine Deficiency Disorders Control Programme (NIDDCP). Policy and Advocacy Meeting on Iodine Deficiency Disorders (IDD), New Delhi, January 17, 1994.
2. Universalisation of Access to Iodised Salt - A Mid-decade Goal. The Salt Department, Ministry of Industry, Govt of India, January, 1994.
3. Sooch SS, Deo MG, Karmarkar MG, Kochupillai N, Ramachandran K, Ramalingaswami V. Prevention of endemic goitre with iodised salt. Bull WHO 1973; 49: 307-12.
4. Ranganathan S, Narasinga Rao, BS. Stability of iodine in iodised salt, Indian Food Industry 1986; 5: 122-124.
5. Proceedings of the Motivation Campaign of IDD Control through salt iodation: March 14, 1992, Udagamandalam, India, Salt Dept, Government of India, Deputy Salt Commissioner, Madras, p 14.
6. Narasinga Rao BS, Ranganathan S. A simple field kit for testing iodine in salt. Food and Nutrition Bulletin 1985; 7(4): 70-72.
7. AOAC. Official Methods of the Association of Official Analytical Chemists. 15th edition. ed. K Helrich. Association of Official Analytical Chemists Inc. Virginia, USA, 1990, p 335.
8. Indian Salt Commissioner. Stability of iodine in iodised salt. Seminar on IDD control through salt iodisation. Salt Commissioner, Government of India, Ministry of Industry, Jaipur, India, 1989.
9. Ranganathan S. Fortification of common salt with iron: Use of polyphosphate stabilisers. Food Chemistry. 1992; 45: 263-267.
10. Ranganathan S, Dillikumar PK, Ramamoorthy P, Vinodini Reddy. Large scale production of iron fortified salt. J Food Sci Technol 1993; 30(3): 166-168.
11. Kelly FC. Studies on the stability of iodine compounds in iodised salt, Bull WHO 1953; 9: 228.
12. Holman JCM, McCartney W. Iodised salt, In: WHO Monograph Ser. No 44, Endemic goitre, World Health Org, Geneva, 1960; 424-426.