Food technology

Large-scale production of salt fortified with iodine and iron

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Abstract

A new dry-mixing process for producing iodine- and iron-fortified salt on a large scale (20 30 metric tons per shift) was developed in salt factories at Valinokkam and Hyderabad, India. Common salt is mixed with 1% sodium hexametaphosphate, 0.5% ferrous sulphate heptahydrate, and 0.0055% potassium iodide or 0.007% potassium iodate in a ribbon blender. Dry mixing is superior to spray mixing and is associated with no operational problems. The fortified salt produced by this method retains the original colour of the unfortified salt, and the distribution of iodine and iron is uniform. The acceptability of the fortified salt is satisfactory, as various food preparations using the product are indistinguishable in colour, taste, and flavour from those containing unfortified salt

Editorial introduction

Two major micronutrient deficiencies limit the performance of the populations of developing countries. Iron deficiency is the most widespread and not only reduces work capacity and increases susceptibility to infection but also affects cognition. The adverse effects of iron-deficiency anaemia in infancy on behaviour and learning are likely to be permanent. The same is true of the effects on subsequent intelligence test performance of the child as a result of maternal iodine deficiency during pregnancy.

Any procedure that promised a feasible way of preventing the damage to children and adults from both deficiencies would represent a major breakthrough in the prevention of these disorders. Iodization of salt is a time-tested, effective, and economical way of eliminating iodine-deficiency disorders in a population, and great progress is being made by UNICEF and WHO in ensuring that countries at risk implement this procedure. The work in India adding iron as well as iodine to salt holds great promise. It now needs to be replicated and confirmed in other populations, climates,and circumstances. It cannot be expected that this will be free of problems. For example, the reviewers pointed out that the process needs a high quality of salt that may not be available in all countries. Moisture content and insoluble trace minerals could be a problem. Storage conditions and required shelf life may vary, and differences in cooking procedures could introduce complications. None of these concerns should detract from the authors' achievement in demonstrating the methodology under the conditions of India and setting an example for other countries.

Introduction

Iron-deficiency anaemia and iodine-deficiency disorders are two important nutritional problems in India [l-3]. Because of the widespread prevalence and severity of iodine deficiency, the government of India has made a policy decision to iodize all edible salt by the end of 1995, and the country is geared up to achieve the goal [4]. A technology was developed [5] to make iron-fortified salt using sodium hexametaphosphate (SHMP) and ferrous sulphate heptahydrate (FSHH), and this technology was successfully transferred to factories for commercial production [6].

Since iron-deficiency anaemia and iodine-deficiency disorders often coexist, the most cost-effective intervention is to fortifiy common salt with iron and iodine simultaneously. Therefore, a formula was developed to produce iron- and iodine-fortified salt [7] that is an extension of the iron-fortified salt formula [5]. Attempts were made for the first time in India to develop a method for the large-scale manufacture of double-fortified salt in factories.

Materials and methods

Studies were carried out in two factories, Valinokkam factory of the Tamil Nadu Salt Corporation, a public sector undertaking of the Tamil Nadu government, and M/s. Jaybharathi Salts Private Ltd., Hyderabad. The Valinokkam factory has the capacity to produce 15,000 metric tons of fortified salt per annum. Common salt from Tutieorin, Veppalodai, Madras, and Covalang was used. FSHH, SHMP, potassium iodide (KI), and potassium iodate (KIO_3) were supplied by M/s. Amit Agencies, Madras.

Continuous production was performed in this factory.

The Hyderabad factory has a capacity to produce 5,000 metric tons of fortified salt per annum.

Common salt obtained from Tuticorin was used; FSHH, SHMP, KI, and KIO_3 were supplied by M/s.

Abhyudaya Chemical and Scientific Corporation, Hyderabad. A batchmixing process was used in this plant.

All the chemicals used in the two factories were of food-grade quality. The composition of the common salt used in the two plants is given in table 1. Iron in the double-fortified salt was tested by the thiocyanate method [8]. Iodine was tested by the method of Kolthoff [9] using orthophosphoric acid in place of sulphuric acid to overcome the interference of iron during iodine estimation.

Valinokkam factory

In the spray-mixing process, an aqueous solution of the chemicals for iodine and iron fortification (table 2) was sprayed over common salt and mixed in the ribbon blender until the distribution of iodine (40 ppm) and iron (1,000 ppm) was uniform.

TABLE 1. Composition of common salt used for iron and iodine fortification and the stability of iodine

Common salt	NaCl	Insolubles	Sulphate	Ca	Moisture	$MgCl_2$	iodine loss
	(%)	(%)	(%)	(%)	(%)	(%)	(%)
Madras	97.6	0.90	0.80	0.72	6.0	0.70	95
Valinokkam	97.5	0.41	0.40	0.57	4.5	0.12	65
Madras	97.8	0.90	0.60	0.65	3.5	0.60	75
Covalong	96.5	1.20	1.30	0.61	3.5	1.10	87
Valinokkam	96.5	0.40	0.60	0.65	3.0	1.10	53
Veppalodai	98.6	0.60	0.40	0.48	3.0	0.40	62
Tuticorin	95.2	0.10	1.20	0.35	2.7	0.80	65
Madras	98.4	0.55	0.70	0.40	2.0	0.54	75
Veppalodai	98.4	0.45	0.90	0.24	2.0	0.30	55
Valinokkam	98.2	0.43	0.57	0.35	1.8	0.80	65
Tuticorin	99.0	0.14	0.30	0.01	1.5	0.04	0
Valinokkam	98.2	0.13	0.30	0.07	1.3	0.07	5
Valinokkam	99.2	0.12	0.13	0.08	1.0	0.03	0
Tuticorin	99.1	0.15	0.20	0.02	0.5	0.01	0
Veppalodai refined	99.5	0.11	0.40	0.01	0.3	0.03	0
Tuticorin refined	99.3	0.10	0.40	0.02	0.2	0.04	0

TABLE 2. Quantity of common salt and chemicals used for iodine and iron fortification

Ingredients	Quantity	
	Hyderabad factory	Valinokkam factory

Common salt (metric ton)	0.1	3
SHMP (kg)	1.0	30
FSHH (kg)	0.5	15
KI (g)	5.5	165
KIO_3 (g)	7.0	210

SHMP, Sodium hexametaphosphate; FSHH, ferrous sulphate heptahydrate; Kl, potassium iodide; KIO_3, potassium iodate.

TABLE 3. Foods used in the acceptability trials of iodineand iron-fortified salt

Type of diet	Diet components
Vegetarian	Chapati, lemon rice, coconut rice,
	dal, chatni, potato curry, various
	vegetable curries, idli, dose,
	upma, pongal, vada, purl,
	pakoda, bajji, vegetable salad,
	lemon juice, curd, fruits, pickles,
	sambar, rasam
Non-vegetarian	Omelette, boiled egg, fish, mutton

The system used for dry mixing is shown in figure 1. The chemicals were thoroughly mixed in a small blender (50-kg capacity), and the mixture having 40 ppm iodine and 1,000 ppm iron was placed with common salt into the crusher in the first stage of preparation. The second stage took place in the feed regulator and the third and final stage in the ribbon blender. Several samples of double-fortified salt were drawn randomly and the distribution of iodine and iron was tested. Then the salt was packed in 1kg packets and transported by road to Hyderabad, where the effect of transportation on iodine stability was studied.

Double-fortified salt was incorporated into various foods (table 3) in place of common salt, and its acceptability was studied in the factory. Foods prepared with unfortified salt served as controls. All the food items were evaluated by 40 volunteers (factory staff, visitors) between age 20 and 50 years. The volunteers were blinded to the presence or absence of double-fortified salt in the food items. They were asked to rate the quality of different attributes by assigning scores from 1 to 5 (I = very poor, 5 = very good). Statistical analysis was done using one-way analysis of variance to test the differences between mean scores allotted.

FIG. 1. Salt fortification, dry-mixing plant. DFS, Double-fortified salt

Hyderabad factory

A stainless steel ribbon blender with a capacity to hold 100 kg of salt was used for iodine and iron fortification by the batch-mixing process. In the spraymixing process, an aqueous solution of the fortification chemicals corresponding to 40 ppm iodine and 1,000 ppm iron was sprayed over 100 kg of common salt in the rotating ribbon blender and mixed for 10 minutes. In the dry-mixing process, the chemicals required for 100 kg common salt equivalent to 40 ppm iodine and 1,000 ppm iron were first mixed with 1 kg of common salt separately, and the mixture was added to the remaining 99 kg in the ribbon blender and mixed for 10 minutes.

After fortification, several samples of double-fortified salt were drawn randomly and tested for the iodine and iron contents. The salt was packed in 1-kg HDPE packets and transported by road to Valinokkam, where its acceptability was tested in the population.

Results

Spray mixing

Both factories encountered several problems producing double-fortified salt by spray mixing. The salt became wet and sticky in the ribbon blender, and this interrupted continuous production in the Valinokkam factory as well as batch mixing in the Hyderabad factory. The ribbon blender had to be cleaned frequently, and therefore the production schedule was affected in both factories. An expensive dryer was required to remove the excess moisture.

The fortified salt developed a pale brown colour. Rapid loss of iodine (95% 98%) occurred during production; in fact, one could see the escaping iodine vapours in the ribbon blender. The iodine content of the fortified salt was 1 to 2 ppm, whereas the initial level of iodine was 40 ppm. Thus, the spray-mixing process was unsuitable for producing double-fortified salt either by continuous production or by batch mixing (table 4).

Dry mixing

No such problems were encountered with the dryixing process in the two factories. The double-fortified salt retained the original colour of the

unfortified salt, with no discolouration even with prolonged storage. The normal production capacity of the two factories was unaltered, and production was uninterrupted. Analysis of several hundred randomly collected samples showed uniform distribution of iron (1,000 ± 50 ppm) and iodine (40 ± 1 ppm). Overall, the dry-mixing process was superior to the spray-mixing process.

TABLE 4. Comparison of production techniques for double-fortified salt (DFS) in the factory

Variable	**Production technique**	
	Spray mixing	Dry mixing
Discolouration of DFS	Pale brown colour	No discolouration
Nature of DFS	Wet and sticky	Free flowing
Cleaning of blender	Frequently	No need
Production schedule	Affected	Smooth
Removal of water	Need for a dryer	No dryer
iodine loss	95%-98%	No loss
Production cost	More	Less
Suitability	Unsuitable	Ideally suited

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