Introduction

Iodine deficiency disorders (IDD) and iron deficiency anemia (IDA) form the major micronutrient deficiencies of public health significance in India; several surveys have indicated that no state in the country is free from IDD and nearly two-thirds of children, women of reproductive age, and adolescent girls across the country are estimated to be suffering from IDA\textsuperscript{1, 2, 3}. The control of micronutrient deficiencies by food fortification is one of the most significant developments in recent years. Probably no other technology available today offers such a wide scope to improve the health and nutritional status of people in the most cost-effective way\textsuperscript{4, 5}. Clearly salt isn’t just another rock, but the rock of life. Next to water, salt is consumed by 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 populations; it has very little likelihood of overdosing; production of salt is limited to few centers; salt is an ideal vehicle for micronutrient fortification and micronutrients like iodine and iron introduced through salt will be ingested by each individual at a uniform dosage throughout the year.

Past

The use of iodized salt in India started with the Kangra Valley study carried out during 1956 – 1962 where three groups were given iodized salt (KI), iodated salt (KIO\textsubscript{3}), and non-iodized salt. The iodized salt group showed a decrease in the prevalence rate of goiter from 38% to 19% over 6 years and to 8.5% over 12 years. Similarly, the iodated salt group showed a decrease in goiter from 38% to 15% over 6 and 9.1% over 6 years and 12 years respectively\textsuperscript{6}. This was in contrast to non-iodized salt group in whom the goiter prevalence rate did not change in 1962. However, introduction of iodized salt in this group also from 1962 onwards resulted in a reduction in overall goiter prevalence from 40.3% in 1962 to 17.1% in 1968. The Kangra Valley study paved the way for the introduction of iodized in the country, initially by Government agencies and later by private firms. Concurrently the National Institute of Nutrition (NIN) focused on the problem of poor iodine stability of iodized salt and solved the problem successfully by using permitted food additives such as carbonates as iodine stabilizers, which inexpensive and cost effective\textsuperscript{7, 8, 9}. The initial iodine level was retained even after one year (Table 1) and there was no migration of iodine from the top layer to bottom layer during long-distance transportation over 2000 km\textsuperscript{8, 9}. Inexpensive, simple, easy to handle and sensitive salt testing kit for monitoring the iodine content of IS was developed by NIN\textsuperscript{10}. 
To overcome the ill effects of IDA four different formulations of iron fortified salt (IFS) were developed by NIN during the period 1975-1996 (Table 2). First formulation used ferric orthophosphate and sodium acid sulphate. Second formulation had ferrous sulphate and ortho phosphoric acid. The efficacy and impact evaluations of two formulations were successful (Working Group on fortification of salt with iron 1982). However, these two formulations had discoloration problem in factories during large-scale production. This was solved by the third formulation using ferrous sulphate and sodium hexa meta phosphate and this formulation showed better iron bio-availability than the first two formulations (Table 2). Large-scale production of this formulation was successfully done in factories and this formulation technology was transferred to factories in Hyderabad and Chennai. Fourth formulation employed ferrous glycine sulphate, an amino acid complex of ferrous sulphate, without the use of any stabilizer/absorption promoter for Iron. Inexpensive, simple, easy to handle and sensitive salt testing kit for monitoring the iron content of IFS was also developed by NIN.

**Present**

As a sequel to the universal iodization of edible salt as a National Policy in the country, NIN evolved the concept of double-fortification of salt (DFS) with iodine and iron for controlling the deficiencies of both these micronutrients in a single measure as ‘one intervention controlling two problems’. NIN-DFS was developed with good-quality food-grade salt (100%); potassium iodate, KIO₃ (0.0067%); ferrous sulfate heptahydrate, FeSO₄·7H₂O (0.508%); and sodium hexa metaphosphate (SHMP) at the 1% level to provide simultaneously about 30-40 μg iodine and 1,000 μg iron per gram of DFS. SHMP is a permitted food additive and is extensively used in the food industry. SHMP in NIN-DFS is intended to protect and prevent the interaction of iodine from undesirable reactions with iron and other constituents of the salt in DFS. Good-quality food-grade common salt (magnesium < 0.10%, moisture < 1.5%, NaCl > 98%) and food-grade chemicals are used in the production of NIN-DFS. Higher levels of magnesium or moisture in salt are detrimental to the stability of iodine in

| Table1: Impact of carbonate stabilizers on iodine stability in iodized salt: Factories studies |
|-----------------|----------------|----------------|----------------|----------------|
| Iodized salt    | Percentage iodine | Initial* | 3 months | 6 months | 12 months |
| With carbonate stabilizer | 100 | 100 | 100 | 100 |
| Without carbonate stabilizer | 100 | 60 | 57 | 50 |
| * Initial iodine: 30 ppm |

| Table2: Bio-availability of iron from iron fortified salt |
|-----------------|----------------|----------------|----------------|
| Formulation | Chemical additives | Iron bio-availability (%) |
| | | Rice meal | Wheat meal |
| 1 | Ferric ortho phosphate + sodium acid sulphate | 4.2 | Not done |
| 2 | Ferrous sulphate + ortho phosphoric acid + sodium acid sulphate | 3.9 | Not done |
| 3 | Ferrous sulphate + sodium hexa meta phosphate | 6.9 | 4.0 |
DFS\textsuperscript{20}. The NIN-DFS showed good stability (Figure 1), satisfactory impact on iodine status (Figure 2) and iron status (Figure 3) and underwent series of scientific studies, which showed satisfactory result\textsuperscript{2,21}.

The salt testing kits for iodine\textsuperscript{10} and iron\textsuperscript{17} can be used for testing the iodine and iron contents of DFS.

The Ministry of Health & Family Welfare, Govt. of India, constituted a Technical Committee under the Chairmanship of Dr. M. K. Bhan, Secretary, Dept. of Biotechnology, Govt. of India on “Formulations of guidelines for use of double-fortified salt as a measure to reduce prevalence of anemia” via letter No. Z 28020/16/2005-

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**Figure 1 Stability of iodine and iron in NIN double-fortified salt over time**

![Graph showing stability of iodine and iron over time]

**Figure 2 Impact of NIN-DFS on iodine status (UIE: Urinary iodine excretion)**

![Graph showing impact of NIN-DFS on iodine status]
CH/PH dated 14th July 2005. The main Committee and the Sub-Committees met as per requirements and analyzed the data available on different formulations of DFS and finally approved only NIN-DFS because of convincing evidence from NIN-DFS based on:

- scientific publications,
- formulation,
- nutrient level,
- process,
- ultra structure,
- salt quality,
- stability,
- organoleptic studies,
- acceptability,
- factory production,
- community acceptance,
- safety evaluation,
- bioavailability,
- iron impact,
- iodine impact, and
- cost. Furthermore, the Dr. Bhan Committee recommended the introduction of NIN-DFS in nutrition programs.22

Based on the recommendations of the ICMR Expert Committee, NIN advertised in all leading newspapers, including vernacular papers, calling for applications from salt manufacturers for the transfer of NIN-DFS technology during 2007. While NIN is not charging for the technology
transfer, the manufacturers would supply at least 20% of the produce to the public
distribution system (PDS) at prices fixed by the Government for the benefit of people
living below the poverty line. Furthermore, NIN has communicated to the Secretaries
of the Women Development and Child Welfare Department as well as Health
Department of all the States and Union Territories in the country, advocating the
introduction of NIN-DFS in nutrition programs of the States and Union Territories.
Also, NIN has played an active role in the development of standards under PFA and
BIS for DFS.

Future

Commercialization of NIN-DFS in the form of supply to government-aided
programmes has taken a definite shape. Already three private firms have started
supplying NIN-DFS to Government programmes through public distribution system

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Firm</th>
<th>Status</th>
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<tbody>
<tr>
<td>1</td>
<td>M/s Prince International Health Care (P) Ltd., Bhubaneshwar, Orissa</td>
<td>Supplying DFS to programmes of Karnataka/Chhattisgarh States</td>
</tr>
<tr>
<td>2</td>
<td>M/s Christy Friedgram Industry, Tiruchengode, Tamilnadu</td>
<td>Supplying to programmes of Karnataka State</td>
</tr>
<tr>
<td>3</td>
<td>M/s Ankur Chemfood Products (Guj.) Ltd., Gandhidham, Gujarat</td>
<td>Supplying to programmes of Himachal Pradesh State</td>
</tr>
<tr>
<td>4</td>
<td>Andhra Pradesh Foods, A Govt. of A.P. Enterprise, Hyderabad, A.P.</td>
<td>Signed memorandum of understanding with NIN</td>
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(PDS) in the States of Karnataka, Chhattisgarh and Himachal Pradesh (Table 3) at
a price of about Rs. 6/- per kilogram. One Public Sector Undertaking has signed the
memorandum of understanding (MoU) with NIN for DFS. Once the notifications of
the Prevention of Food Adulteration Act (PFA) and the Bureau of Indian Standards
(BIS) are published these firms will be in a position to provide DFS in the consumer
market at affordable price. Others have made attempts to fortify salt with vitamins
and other trace elements, in addition to iron and iodine by costly encapsulation
methods. But these attempts will increase the cost of fortified salt alarmingly.
Furthermore, the interplay of the additives in salt is not known.

Thus, common salt was successfully used in the past for the control of IDD through
iodized salt and by iron fortified salt to control IDA in the country. Then double
fortified salt (DFS) as a single strategy to overcome both IDD & IDA simultaneously is
picking up at present. Future will generously use DFS at consumer level at an
affordable price in order to overcome the twin burden of IDA and IDD in the country.
NIN’s salt testing kits will find a place to test the iodine as well as iron levels in
fortified salt at retail and consumer levels.
References


22. Bhan Committee. Recommendations of the Technical Committee on “formulations of guidelines for use of double-fortified salt as a measure to reduce the prevalence of anemia”. Ministry of Health and Family Welfare, Govt. of India: Under the Chairmanship of Dr. M. K. Bhan, Secretary, Dept. of Biotechnology, Govt. of India, 2006.