Micronutrient Initiative

SOLUTION IN A PINCH

The Micronutrient Initiative's Double Fortified Salt strategy tackles two problems in one go

Addressing iron and iodine deficiencies in the most vulnerable

Micronutrient Initiative




THE POWER OF SALT

"With this salt, I am shaking the foundations of the Empire"

– Mohandas Karamchand Gandhi

SALT WAS AN UNLIKELY WEAPON employed by Gandhiji in India's freedom struggle.

Can salt now be the vehicle to take India on the path of eliminating iron deficiencies?

In 1994, the Micronutrient Initiative began taking active part in an experiment to fortify iodised salt with iron. The technological breakthrough was achieved in 1998. Field trials, efficacy tests and consumer acceptability surveys conducted subsequently have demonstrated the viability of the Double Fortified Salt (DFS).

Today, DFS has emerged as an exciting intervention that works complementarily with other approaches to tackle iron and iodine deficiencies, which affect half the world's population. The technology is available in India and transferable. Here then is a powerful new solution which India and other nations can use to address anaemia.

CONTENTS

THE SALT OF LIFE

Spicing up a village school lunch

"Up Illa Pandam Kuppai Le
UP Irinda Toppai Le"

– Tamil Proverb

(A food item without salt goes straight into the waste bin, if there is salt, it goes into the stomach)

ON THE MAP IT'S HARD TO LOCATE Melakidaram, a tiny village in coastal Tamil Nadu, with less than a thousand households. It is equally tough to find it by road, as you negotiate miles of desolate landscape. In this remote village in drought-prone Ramnad district neither agriculture thrives nor is there any industrial activity of note.

And yet the Government Higher Secondary High School breaks many stereotypes. Like most village schools in India, you will find the odd cow, goat and hen wandering freely in the school compound. But, unlike other such academies where students sit on the floor, here the classrooms boast chairs, desks and blackboards. The school has a computer centre, and has a creditable pass percentage of 84 per cent in 10th standard. Most students continue up to Class 12. The teachers are proud that there are as many girls as boys attending the school, with the total of 508 students split neatly into 254 boys and 254 girls. The students look bright-eyed and cheerful.

As the bell rings announcing lunch, students pour out of the classrooms to queue up for their noon meal. A pesky goat joins the children in the queue and butts his way ahead, only to be pushed away firmly.

Today, the menu at school is rice, boiled eggs and *sambhar* (a preparation made with lentils), a meal prepared using double fortified salt (DFS), a special kind of salt that contains both iron and iodine. The two micronutrients are critical for mental and physical development. Since 2005, through the Tamil Nadu state-sponsored mid-day meal scheme, the school has been getting DFS in its monthly rations.

As the children attack their food, teacher Bhuvaneshwari reveals that the school has a lot to thank salt for. The teachers believe that the nutritious mid-day meal, prepared with DFS, contributes to the energetic enthusiasm of the students (and ensures attendance), while the salt factory nearby is the generous benefactor of furniture to the school. The Tamil Nadu Salt Corporation (TNSC) at Valinokkam also employs many of the children's parents.

Melakidaram's school girls enjoy a mid-day meal that is sprinkled with healthy seasoning

Take Jayalakshmi, who has been working as a salt worker for the last 22 years. Her daughter, Alaga Devi, attends the government school. Over 2,500 villagers from neighbouring areas have gained the security of regular jobs and can send their children to school.

While industrial salt is the main production of the unit, TNSC, with technical and financial assistance from the Micronutrient Initiative (MI), produces both iodised and double fortified salt. MI's DFS program was undertaken with the financial support of the Government of Canada provided through the Canadian International Development Agency (CIDA) and the World Bank. Millions of children in Tamil Nadu are beneficiaries of this pioneering program.

In the pages ahead is the story of some unlikely partnerships – the tale of how iron and iodine were taught to coexist in a common compound. And how a Canadian non-profit organisation and an Indian public sector undertaking came together to showcase how a pinch of salt can make a difference in the lives of many.

TWIN BENEFIT
Double Fortified Salt (DFS) is an edible salt fortified with iodine and encapsulated iron. At 10 g/day of daily consumption of salt, a person can receive 10 mg of iron per day – that's around one third of their daily requirement of iron. Millions of school children in Tamil Nadu get DFS in their mid-day meal.

THE INVISIBLE ENEMY

The global impact of iron and iodine deficiencies

Children at a village school in Tamil Nadu: 51 per cent of girls in Tamil Nadu are anaemic, according to NFHS-3

AROUND 2 BILLION PEOPLE ACROSS THE world are anaemic and at least a half of it is due to iron deficiency, according to the World Health Organization (WHO). Iron deficiency is, in fact, the single-most common nutritional disorder affecting the global population, and the prevalence is disproportionately high in developing countries.

In India, nearly 70 per cent of women and 75 per cent of pre-school-age children are estimated to be iron deficient. Despite making rapid economic strides in the last couple of decades and being considered a global success story, India has been unable to address many of the nutritional deficiencies among its people. Tackling iron deficiency, especially, is a huge challenge for the country. Every year between 70,000 and 150,000 women in India die during child birth, in part due to iron deficiency anaemia (IDA).

IDA during pregnancy increases the risk of fetal growth retardation, low birth weight, haemorrhage during delivery and premature delivery. Iron deficiency can also lead to cognitive losses in young children, reducing mental abilities (including IQ). And, inadequate intake of iron makes adults, mothers and babies more susceptible to infections.

All of these impacts of iron deficiency on individuals can result in economic consequences for the country. It is estimated that nations suffer losses of up to 2 per cent of Gross Domestic Product (GDP) due to iron deficiency as a result of lower productivity in manual occupations for adults. Eliminating anaemia would lead to up to 17 per cent increase in adult productivity in the most affected countries. Significantly, IDA affects all socio-economic groups.

Although nations have tried hard to close the iron gap, the problem persists. What is needed now is a drastic intervention – a solution like DFS that can work in tandem with other approaches.

IRON DEFICIENCY KNOWS NO BARRIERS

Rich or poor, iron deficiency impacts everyone. A World Bank paper reveals that while anaemia rates are higher for the lower wealth quintiles they are still high even in the wealthiest 4th and 5th quintiles.

INDICATOR	WEALTH QUINTILE					
	Low	2nd	3rd	4th	High	Avg.
Children						
Mild anaemia	23.3	22.6	21.9	22.4	23.8	22.8
Moderate anaemia	49.6	50.5	47.4	44.3	36.4	46.2
Severe anaemia	5.9	5.9	5.8	5.6	3.7	5.5
Women						
Mild anaemia	40.3	38.2	34.8	32.5	30.3	35.2
Moderate anaemia	19.8	16.8	14.5	13.3	10.2	14.9
Severe anaemia	2.6	2.1	2.2	1.6	1.1	1.9

India: Socio-economic differences in health, nutrition and population. Working paper 39447, 2007

RED ALERT ON ANAEMIA!

Addressing anaemia is a huge medical, social and developmental challenge for nations all around the world. The most important cause for anaemia is inadequate dietary intake of iron. Other causes include poor bio-availability of iron in phytate fibre-rich diet; infections such as malaria, hook worm infestations; and standard of living.

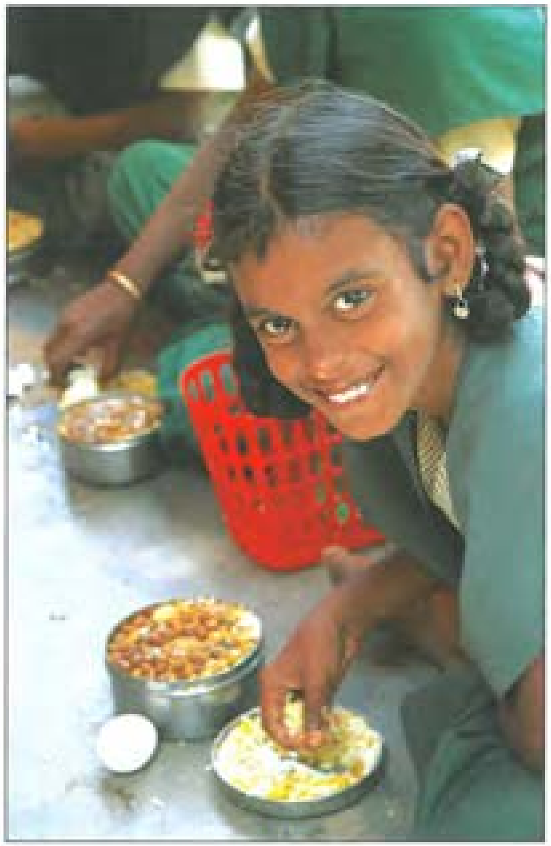
Currently, nations have tried three major strategies to improve iron nutrition:

- Supplementation – provide iron supplements, especially to those at risk, such as pregnant women and adolescent girls
- Dietary diversification – increase the iron content of the diet
- Fortification – fortify common food staples with iron

However, all approaches have some limitations. Accessibility and poor compliance are inhibiting factors in the supplementation strategy, while cost and time taken for significant results to be achieved are limitations of the dietary diversification approach.

Food fortification has been tried out in wheat, rice, and other cereals with varying degrees of success. For any fortification vehicle, a challenging proposition is to find a common staple in a country with a diverse dietary pattern. Reach and supply also limit fortification's effectiveness.

In addition, there are iron absorption issues. Even when high iron-containing products are ingested, not all of the iron is absorbed, as bioavailability differs between foods. Fortification with iron also needs technical considerations because iron reacts with several food ingredients.



World over, efforts have been on to find a universal fortification strategy for iron that works, something that would be as effective as Universal Salt Iodisation. The challenge has been to find a food product that is universally consumed which will not react with high bio-available forms of iron. In recent years, researchers in Guatemala have experimented with fortifying sugar with iron. In China, fortifying soy sauce with iron has met with some degree of success. In India, MI has developed targeted approaches to meet the micronutrient requirements of children through a multiple micronutrient product called Anuka that is added to complementary food and 'Vita Shakti', which is added to foods cooked for institutional feeding programs.

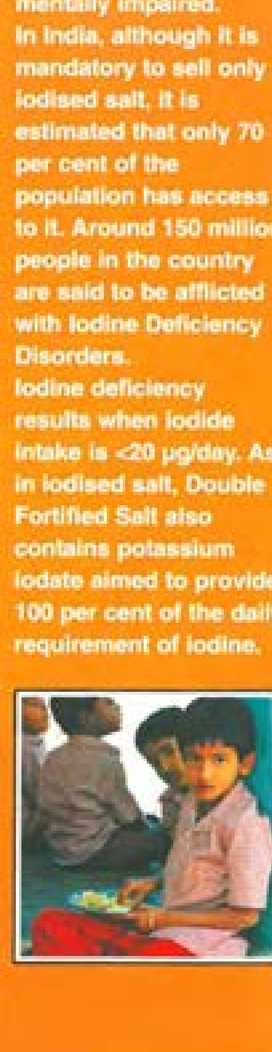
In the successful control of micronutrient deficiencies, exploration of new options is an ongoing effort. **Though there is no one solution that can address the problem, an integrated combination of strategies that work is important**. In this milieu, the technical break-through achieved in fortifying iodised salt with iron and thereby delivering a double dose in just one tiny pinch is an exciting development that holds promise with a potential for universal reach.

THE CASE FOR IODINE

Iodine deficiency is the world's leading cause of preventable mental disability. Estimates suggest that it has lowered the intellectual capacity of millions of people in hundreds of nations by as much as 10 to 15 percentage points. Iodine deficiency in pregnancy causes 18 million babies a year around the world to be born mentally impaired.

In India, although it is mandatory to sell only iodised salt, it is estimated that only 70 per cent of the population has access to it. Around 150 million people in the country are said to be afflicted with Iodine Deficiency Disorders.

Iodine deficiency results when iodide intake is <20 μg/day. As in iodised salt, Double Fortified Salt also contains potassium iodate aimed to provide 100 per cent of the daily requirement of iodine.



SOLUTION IN A PINCH OF SALT

The birth and development of double fortified salt

"The Salt of Patience seasons everything"

FROM THE DAWN OF CIVILISATION, SALT HAS played a key role in human lives: in shaping our history, our economy, our politics, our culture and our very civilisation.

Today, this basic compound, which is found in plentiful quantities across the world, also delivers life-sustaining nutrients like iodine to billions of people. Salt has been the vehicle on which one of the world's most successful public health campaigns – the Universal Salt Iodisation program – has ridden.

In just two decades a major proportion of the world's salt has been iodised. What this shows is that salt is the only true example of a food that is globally fortifiable, which can reach one and all.

As Venkatesh Mannar, President of the Micronutrient Initiative, says, "Practically everyone uses salt, making it the most natural vehicle for fortification. Also, there is a very narrow band of consumption – not more than 10 to 15 gm per day, so there is little danger of overconsumption."

There are several advantages of using salt in iron fortification. For example, in India, although salt is processed in multiple locations, it is all within a manageable geography. Ninety-seven per cent of India's salt is produced in just three states – Gujarat, Tamil Nadu and Rajasthan. The same is true in many of the world's salt producing countries.

A staple in most kitchens around the globe, salt is also relatively inexpensive. What's more, people use about the same amount every day to flavour their food, which means there will be a consistent delivery of nutrients that the salt carries.

Significantly, the Codex Standard Alimentarius Commission (created by FAO and WHO in 1963 to establish global food standards) permits the use of salt as a carrier for nutrients including iron.

So, given all these benefits, why hasn't salt been used all these years to deliver iron and other key micronutrients?

The idea has been around since 1969 but it has taken a lot of time to develop a commercially viable technology where both iron and iodine can coexist in salt in a stable form.

THE SCIENCE BEHIND DOUBLE FORTIFIED SALT (DFS)

On paper, adding iron to salt looks a simple solution. But as Mannar explains, "Introducing iron to salt, especially iodised salt, adds a complexity one can't imagine."

When food engineers first tried to fortify iodised salt with iron, a broad array of chemical, technical, and organoleptic problems cropped up including:

1969	1993	1994	1995
Food Technology Journal publishes article about the possibility of delivering multiple micronutrients through salt	The idea of working on double fortified salt proposed by Venkatesh Mannar to the University of Toronto	Venkatesh Mannar joins Micronutrient Initiative as Executive Director and brings DFS project to MI	MI arranges financial support for U of T's DFS premix project through grants from the Canadian International Development Agency and the World Bank

Levente Diosady and Ildiko Ralleanu (University of Toronto); Venkatesh Mannar, Annie Wesley and Satyapal Jayapal (Micronutrient Initiative)

- Instability of iodine compounds in the presence of iron and impurities in salt
- Oxidation of ferrous compounds
- Unacceptable colour formation. Water-soluble iron compounds, which are the most bio-available, react with moisture and impurities in salt and develop an unappealing colour and taste
- Natural dark colour of some iron compounds that are not acceptable

But ingenuity knows no barriers and, as a result of concerted research, scientists had achieved a breakthrough method to overcome all these challenges. Interestingly, scientists were working in parallel on DFS technology in at least four different places – University of Toronto in Canada, the National Institute of Nutrition, Hyderabad, India, Swiss Federal Institute of Technology (ETH), Zurich and at the Akzo Nobel labs in Sweden.

The Micronutrient Initiative worked with the University of Toronto (U of T) program and arranged financial support as well as technical input.

On the research front, the project was led by Prof. Levente Diosady, Professor of Food Engineering, Department of Chemical Engineering and Applied Chemistry, U of T.

Essentially, there were two stages involved in the process of double fortifying salt. The first stage was to develop and produce an iron premix. The next was the preparation of the double fortified salt itself.

Under Dr. Diosady's guidance, as the researchers set out to work to create an iron premix, the first task was to identify a suitable iron compound. The team screened more than 10 iron compounds before settling on ferrous fumarate. This compound was chosen as it was comparable to the standard ferrous sulphate in bio-availability but did not have its strong flavour. Also, a review of scientific literature showed that ferrous fumarate was an iron compound commonly used in food applications as well as in iron tablets that were being prescribed by doctors for preventing and treating anaemia.

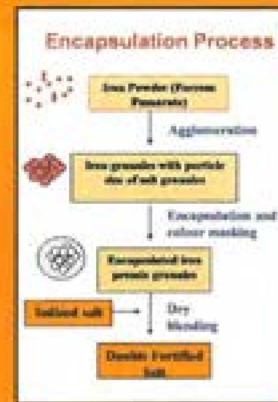
The next task was to identify an agglomeration technique to bring the particle size of the ferrous fumarate, which was too fine, close to that of salt.

The final task was to come up with a method of ensuring that iodine and iron stayed separate. Initially, the scientists worked at creating a barrier around iodine, but after some time they abandoned this approach and turned their attention to iron instead. After trying out many methods, encapsulation or coating of iron was found to be the best process to achieve a stable and acceptable premix for the production of DFS.

Subsequently, food engineers worked on improving the product performance by using small quantities of stabilising and colour-masking compounds.

Over the years the iron premix formulation was further fine-tuned at Glatt Air Techniques, New Jersey, USA, where it was pilot tested for commercial production.

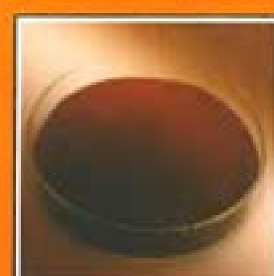
The final proof – acceptance by consumers and perceptible improvements in haemoglobin levels after consumption – came from controlled trials, described in later pages.



THE EUREKA MOMENT!

"We finally solved the problem of keeping iodine and iron together in the salt, by borrowing a technique from the food industry referred to as microencapsulation. The process involves spraying iron particles with stearine, a vegetable fat which creates a protective coat and prevents the iron from reacting with the iodine."

– Prof. Levente Diosady, University of Toronto



1997	1998	1999	2000
Technical problems are overcome and a successful barrier created between iron and iodine through encapsulation	Tests on bioavailability of the iron and iodine, including absorption tests in humans	Consumer acceptability tests in Bangladesh, Ghana and Guatemala successfully show the DFS is acceptable when used in a variety of local foods	Tests on efficacy of the DFS in preventing anaemia in non-to-mildly anaemic women and their children in Ghana

Micronutrient Initiative

FROM THE LAB TO THE FIELDS

DFS passes the test with flying colours

BY 2001, A VIABLE IRON PREMIX (ALSO CALLED DFS premix) was ready for scale-up – all the major lab tests had been done and the product showed excellent results. It was time now for a situation assessment and move to the fields. Nigeria and Kenya were selected for field testing as the salt produced in these two countries met the quality requirements for DFS.

Salt producers in these countries participating in the program were provided with assistance by MI, in collaboration with UNICEF, to procure the equipment necessary for the premix addition. Support was also provided for mixing and quality control.

The fortification process is extremely simple – the technology has been conceived in such a way that any salt processor who produces iodised salt can implement it at his or her end, by investing in simple blending equipment. The DFS premix is added to the iodised salt just before the packaging stage.

To get the right levels of iron in the salt, a key stage in the blending process is to correctly weigh and measure the premix. For example, the DFS premix containing encapsulated ferrous fumarate is blended with iodised salt at a ratio of 1 to 150 to produce DFS containing 1,000 ppm of elemental iron. In practical terms, 1,000 ppm of iron provides 10 mg of iron per day at an average salt consumption level of 10 g/day – that's around one third the daily requirement of iron. The technical team also took into account the recommendation on reduced salt intake and standardised the procedures. For example, if a population's salt intake averages 5 g/day the blending ratio of premix to salt is kept at 1 to 75 to provide 2,000 ppm elemental iron to maintain 10mg of iron per day.

SENSORY TESTS

Sensory acceptability trials were carried out in various locations in Kenya and Nigeria. The objective was to evaluate the appearance and the acceptability of the DFS in local foods. More than 100 consumers participated in the sensory evaluation in each country using over 20 local food recipes.

The findings indicated that the DFS compared well with the control (local) salt in its sensory attributes except in its appearance, where the control salt was slightly preferred. All the dishes were found to be acceptable to the consumers.

STORAGE TESTS

Storage tests were carried out to understand the product quality and stability of DFS at laboratory room temperatures, accelerated temperatures of environmental test chambers as well as during typical distribution networks in hot humid climates. During a study on distribution and storage in coastal and high land zones in Kenya, packets of DFS were transported in sealed polythene bags, with a datalogger device for monitoring temperature and humidity. Monitoring was done throughout the distribution chain, from the salt manufacturer's facility to the consumer. Observations after three months showed

MAY 2000	2001	2002	2003
At the 8th World Salt Symposium, MI unveils its first DFS product to the world, using encapsulated iodine	Research continues on masking the colour of ferrous fumarate (iron compound). By end 2001, encapsulated ferrous fumarate formulation was found to prevent interaction with iodine without disrupting existing salt iodisation practices	Field trials start in Nigeria and Kenya	Pilot scale production of premix at Glatt Air Techniques, NJ, USA

that the encapsulation of iron protected both the iodine and ferrous iron during distribution and retail in typical tropical conditions. It was observed that even during adverse climatic conditions, most of the ferrous iron was retained with less than 17 per cent oxidised to ferric state. A parallel stability study in Nigeria's coastal and northern highlands over a five-month period confirmed that the DFS was stable with over 70 per cent iodine retention.

More recently, a 10-month study in India by St. John's Medical College, Bangalore, has shown that there is no difference in iodine stability between the encapsulated ferrous fumarate (EFF) based DFS salt and iodised salt – both salts (with 1.8 per cent moisure) lost 20 per cent of their iodine content after 6 months.

BIO-AVAILABILITY TESTS

Initial tests on absorption levels in healthy adults by the Departments of Paediatrics and Nutritional Sciences, University of Toronto, on salt fortified with non-encapsulated Ferrous Furmarate and encapsulated iodine, had shown that both the nutrients were well absorbed. In 2000, a study in Ghana established that the DFS was efficacious in reducing the prevalence of anaemia in children by 23 per cent over an eight-month period. Later, when it was decided to encapsulate the iron compound instead of iodine, an additional bio-availability study was conducted at the Swiss Federal Institute of Technology, Zurich. Study results showed that encapsulation did not reduce the bio-availability of the iron compound.

A respondent in the field study in Karnataka conducted by St. John's Medical College, Bangalore

In India, controlled trials were conducted by St. John's Medical College, Bangalore and Swiss Federal Institute of Technology in 18 villages in Anekal Taluk, Karnataka, where families were randomly assigned to receive either iodised salt or one of the two types of DFS. Haemoglobin, iron status and urinary iodine were measured at baseline, five months and ten months. Results showed that after the 10-month intervention period, the DFS significantly improved the iron status in children and reduced the prevalence of anaemia.

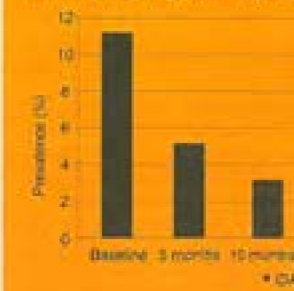
CONSUMER ACCEPTANCE STUDIES

Will consumers be willing to replace iodised salt with DFS? Independent studies conducted in Africa and India say yes. In Kenya, consumer tests were conducted at three sites: urban areas of Nairobi, a rural area in Mombasa, and food aid/refugee sites in Kakuma and Daadab camps. Consumers were provided with DFS to be used in their daily cooking, while those in refugee camps had their regular salt substituted with DFS in their food basket for three months. Respondents were asked about taste, colour and overall acceptability. Results showed that both colour and taste attributes were acceptable in all three areas, and replacing regular salt with DFS did not affect the salt consumption patterns.

Meanwhile, in India, a three-month study was conducted to investigate the acceptability of DFS. DFS was compared to the acceptability of iodised salt in two villages in Haryana. Overall, while both salts were well accepted, iodised salt was the best preferred as it was closest in appearance, colour and taste to the salt already in use by the community. Sensory trials to investigate the acceptability of the salts in prepared dishes found no major differences in the preparations cooked with either of the salts. When the importance of the iron was explained, there was a general willingness in the community to buy the DFS at a nominally higher price in view of its health benefits.

2004	2005	2008	2009
MI enters into agreement with Tamil Nadu Salt Corporation (TNSC) to produce DFS at its Valinokkam plant	DFS premix technology transferred to Mumbai, India. DFS from TNSC introduced in mid-day meals in Tamil Nadu	Bangalore study proves efficacy of DFS in raising haemoglobin levels and addressing iron deficiency among primary school children	Scale-up strategies and program expansion

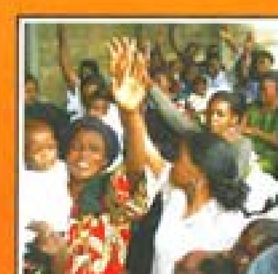
Efficacy of DFS on prevalence of Iron Deficiency Anaemia (IDA)



ACCEPTABLE ON ALL COUNTS

Various tests and studies carried out by MI and independent agencies confirm that the DFS is:

- **Stable during storage and transportation**
- **Biologically available**
- **Acceptable to consumers**
- **Effective in reducing iron deficiency anaemia**



THE MAKING OF DFS

Producing salt is a relatively simple and inexpensive operation

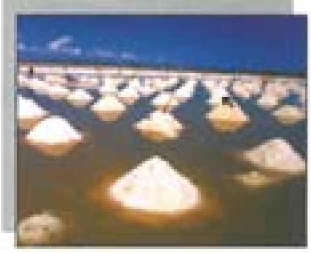
Salt production at the Valinokkam plant of the Tamil Nadu Salt Corporation, India

1 Sea water being pumped in through 7-km long pipeline

2 Sea water being stored in salt ponds

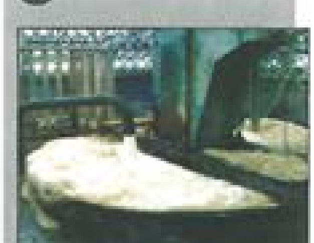
3 Through natural evaporation ponds get converted into salt fields

4 Salt raked into piles after evaporation



5 Workers take the salt to the factory for washing and crushing

6 Salt being washed



7 Salt being iodised

8 DFS Premix being measured out

9 DFS batch being prepared in special blending machine

10 Packaging of salt

11 Branded 1 kg packs of DFS

"Salt is born of the purest of parents: the sun and the sea."
– Pythagoras (580 – 500 BC)

A VIABLE SOLUTION

Benefits far outweigh costs in the DFS program

THE COST-BENEFIT RATIO OF IRON FORTIFICATION
Using various economic models, calculations suggest that the benefit: cost ratio for long-term iron fortification programs would range from 6:1 to 36:1, the latter including the discounted future benefits attributable to cognitive improvements.

IN 2008, A GROUP OF WORLD-RENOWNED economists ranked food fortification with micronutrients (vitamins and minerals) among the top three international development priorities. Specifically, fortification with iron and iodine, two minerals that are needed in small quantities in daily diets, was ranked as a top public health intervention priority for countries using benefit-cost analysis.

The cost of fortifying salt with iron and iodine will mean spending an additional 20 cents per person a year. Not a significant amount, on the surface. And, yet, if you consider this means potentially increasing the retail price of salt by 50 per cent, then the cost assumes significance – especially for low-income consumers. Unless of course, this cost is subsidised by the government.

However, if we weigh the additional costs in the context of the benefits of providing iron to populations that are deficient, this amount looks insignificant.

Economic analysis has shown that improving iron status of deficient adults improves their productivity in heavy manual labour by up to 17 per cent and in light manual labour by up to 5 per cent contributing to improved income generating potential. Studies also confirm that children with adequate iron status interact better with others and have improved cognition as well as perform better in school, and hence the potential for higher lifetime income.

Although DFS cannot be expected to replace iron tablets, powders and syrups for young children and pregnant women or deworming drugs for the most vulnerable, as a complementary approach, it is a highly cost-effective way of addressing iron deficiency anaemia. This was the conclusion reached by an independent review led by external experts from the Friedman School of Nutrition Sciences, Tufts University, USA and a technical consultant from South Africa.

The most compelling argument for using DFS as a strategy to combat anaemia comes from using the PROFILES model, developed by the US-based Academy for Educational Development. A total of 7 million perinatal deaths annually are attributable to iron deficiency anaemia in five countries (India, Bangladesh, Indonesia, Kenya and Nigeria). When economic losses are calculated, the total value of lost productivity due to anaemic adults comes to US$ 3 billion and adding lost future productivity attributable to children brings the potential economic losses to US$ 4 billion.

Using a conservative way of predicting attributable to DFS in this project, the model predicts preventing 43,000 perinatal deaths/year due to improved iron status and gaining US$ 293 million/year as a result of improvements in current and future productivity.

BRINGING THE TECHNOLOGY TO INDIA

A cost advantageous move

Fluidised Bed Processor and accessory equipment used for the agglomeration and encapsulation of the iron compound

THE MOST SIGNIFICANT DEVELOPMENT OF MI'S DFS program has been the successful transfer of DFS premix manufacturing technology to India. Until 2003, the DFS premix was being manufactured at Glatt Air Techniques in the US. However, in order to bring down costs, so that the DFS produced would be within reach of the target population within the bottom quintile of society, MI began exploring other locations.

Mumbai-based Pam Glatt Pharma Technologies Pvt Ltd, a joint venture between German firm Glatt and Indian firm ACG Worldwide, emerged as the most suitable collaborator. A leader in fluid bed processors and tablet coating systems in India, Pam Glatt already had the equipment needed to make the iron premix formulation.

In early 2005, Professor Diosady from the University of Toronto, with a team of MI staff and consultants, led the technology transfer, which was surprisingly smooth. "Within two trials, we got the product quality right," says Dr. Shirish Dhande, Sr. Vice President, Operations at Pam Glatt.

Manufacturing of premix started in March 2005 and since then production has been continuing on a regular basis. Bringing the technology to India has meant huge cuts in cost of premix manufacture, even as the same stringent quality control standards are being met. Now the additional cost of adding iron to iodised salt is US$ 0.04 per kg of salt. Research is underway to examine ways to further reduce the cost. Pam Glatt's Dr. Dhande says that if more volumes of premix are produced, then costs can be brought down.

Essentially there are ten stages in DFS premix production:

- **Sourcing raw materials:** This includes ferrous

fumarate and stabilising and coating agents. Only pharma-grade materials of certified quality are used

- **Solution preparation**: This takes about one hour and is done in preparatory vessels
- **Granulation or agglomeration**: The solution is transferred to fluid-bed processor where in a five-hour-long process, the particle size of ferrous fumarate is increased
- **Screening or sieving**: Using mechanical filters, each batch of ferrous fumarate that emerges from the granulation process is checked and oversized particles rejected
- **Hot melt solution preparation:** It takes about one hour to prepare the solution for coating the ferrous fumarate
- **Hot melt coating:** This encapsulation process again takes place in the fluid bed processor where all the particles of iron are sprayed with the coating agent, and takes about 90-minutes
- **Screening particles:** Again particles are sieved. This takes about half hour. Oversized particles are rejected
- **Blending:** Premix from different lots are blended and separated in one ton packs
- **Quality testing:** Stringent tests are undertaken to check for iron content as well as microbial contamination and other quality parameters
- **Packing:** The iron premix is weighed and packed in 50-kg food grade polybags

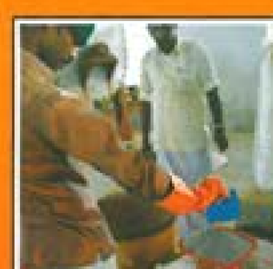
Today, the Pam Glatt facility has the capacity to produce 200 kg per day of iron premix, averaging about 4 tons per month. The company plans to increase its production capacity up to 500 tons of premix per annum. The MI has also transferred the technology to another company in Mumbai which can produce additional premix if required.

THE DFS PREMIX FORMULA

DFS *Premix* includes EFF, soy stearine, titanium dioxide, hydroxypropyl methylcellulose, and sodium hexametaphosphate. The recommended shelf life is 24 months from the manufacturing date in air-tight packed condition.

DFS PREMIX DESCRIPTION:

Appearance
Light gray coloured coated granules
Iron content
14-16%
Particle size
250-800 microns
Dissolution
40-60 mg/g
Coating thickness
14-18%



CASE STUDY
How MI tied up with TNSC to reach millions

To prove that mass fortification through DFS among the most vulnerable is a viable strategy, MI undertook a pilot project in India in Tamil Nadu in partnership with the Tamil Nadu Salt Corporation (TNSC), a state government undertaking. TNSC was chosen by MI as a suitable partner as it had the interest, necessary capacity, scale and distribution muscle to supply to the target group of beneficiaries at the bottom of the pyramid. Since the DFS technology was already transferred to India, it made sense to try it out first in the country.

Spread over 5,600 acres, TNSC produces about 150,000 tons of industrial and food grade salt. Significantly, for MI's DFS program, TNSC was already supplying iodised salt to the state government's mid-day meal program. The state government authorities were amenable to the idea of replacing the iodised salt with DFS.

The project commenced in 2004, when MI equipped the TNSC's Valinokkam salt manufacturing facility with blending equipment for production of DFS.

The first batch of DFS was initially distributed to seven anaemia-prone districts in the state – Trichy, Nilgiris, Salem, Namakkal, Dharmapuri, Karur and Perambulur. Very soon, production was scaled up and DFS began reaching all 29 districts of Tamil Nadu. By 2008, TNSC was producing 300 tons of DFS per month benefitting 3.6 million students through the Mid-Day Meal Scheme.

Although Tamil Nadu has above average performance in various health parameters, nutrition continues to be a challenge in the state *(see box)*. The DFS pilot program was considered especially feasible in Tamil Nadu because not only was this a big salt producing state but also had a successful mid-day meal program (it was one of the pioneers of the school meal program in India). Also, reaching out to younger, pre-school children from low-income groups was feasible in the state, as Tamil Nadu had a good network of Integrated Child Development Scheme (ICDS) Centres (known as *Anganwadis*).

In 2006, TNSC also managed to get a contract to supply DFS for noon meal programs for a limited period in neighbouring Karnataka and parts of Andhra Pradesh.

In just four years, the program has demonstrated that it is easy to integrate addition of DFS with other on-going government programs such as Noon Meal Schemes, and ICDS as well as the immense potential for scale up that exists.

For instance, the TNSC has been in talks with the state government's Public Distribution Services (PDS) system to make the special salt available at all PDS outlets (where most of the poorer

# of school children in India

section shop for their rations). This move would extend the coverage to adult populations as well, including women of child-bearing age and pregnant and lactating women who are particularly vulnerable to iron deficiency anaemia. TNSC officials figure that over 10 million adults can be reached by distributing through PDS.

The scale up possibilities do not end there. Eventually, the idea is to reach out to middle income through social marketing approach. Office canteens at government undertakings and private sector firms can also be encouraged to use the DFS salt.

Achieving higher volumes will also help TNSC lower the costs of DFS. Operating with a subsidy, TNSC could reach the special salt to school children at an additional cost of 1 paise per meal. However, without the subsidy the cost will be substantially higher and the state government undertaking is trying to find solutions so that it can still provide DFS at an affordable rate, without incurring losses at its end.

It's still early days in the program, but the results and outcome have already provided an encouraging model to follow.

THE IRON CHALLENGE IN TAMIL NADU

- **73 per cent of children 6-35 months are anaemic; 4 per cent severely anaemic**
- **Anaemia is widespread in every group in Tamil Nadu and irrespective of age, gender, wealth, location or education**

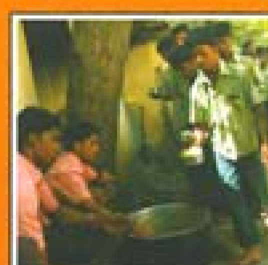
* Girls – 61 per cent & Boys – 67 per cent
* Urban – 65 per cent & Rural – 63 per cent
* Lowest household – 64 per cent
* Wealthy households – 52 per cent
* Children whose mothers have no education – 67 per cent
* Children whose mothers are educated – 57 per cent
* 53 per cent of women age 15-49 anaemic
* 58 per cent pregnant women and 59 per cent breastfeeding mothers anaemic
* 17 per cent men anaemic *(Source: NFHS-3, 2006)*

THE ECONOMICS OF DFS MID-DAY MEAL PROJECT IN TAMIL NADU

- **Cost per ton – Rs. 5,000-5,500**
- **Cost per gram – 0.50 paise @ 2g salt/child, it works out to 1 paise per meal**

The Advantages

- **Low cost per person to receive a regular dose of iron**
- **Ease of integration into on-going programs**
- **Ease of monitoring impact through surveys and studies**



A CHILD CARE CENTRE IN INDIA SPREADS THE MESSAGE

Not too far from the Meenakshi temple, the centerpiece of Madurai town, at Children's Centre No. 164, little Divya is learning the alphabet along with 24 other children. Since morning the children at this government run *anganwadi* have been kept busy by their teachers P. Sankarammal, K. Rukmini and R. Theerthakarai, who have been teaching them songs as well as putting them through a set of physical exercises.

Lunch is a tad delayed today, and the children, who are in the 2-5 age group, are getting cranky. But even as the *khichdi* (a rice and lentil mix) is served, the famished kids do not attack it but sit still. At a signal from the teachers, they close their eyes and recite a prayer and only then set about eating.

By the time lunch is over, Rajeshwari arrives to pick up Divya. She is a housewife and leaves Divya here only in the mornings. The nutritious mid-day meal is an incentive for her to bring Divya to the child care centre. Rajeshwari is aware that Divya gets a special salt in her noon meal. She says the *anganwadi* workers have told all the parents about it, and even did the iodine test in front of them. She also says she and her husband K. Janakiraman tried getting the salt at the local PDS outlet but were told it was not yet available. "Whenever it becomes available, I will surely switch to the special salt," she says.

The *anganwadi* cooks S. Saroja and M. Manimekhalaya, who are listening in, chip in with their bit when they sagely tell Rajeshwari that the salt should be added to food preparations towards the end and not right at the beginning of the cooking process.

SCALE UP STRATEGIES: THE WORLD

Building up momentum in high burden countries

A TIME TO GET TOGETHER

Double fortification of salt calls for multi-sectoral collaboration between:

- **Scientific community:** Come up with solutions and technology
- **Governments:** Advocacy, resources and program support
- **Industry:** Production, technical input, resources and marketing
- **Consumer organisations:** Consumer education to create demand pull
- **NGOs:** To play the role of advocacy and create awareness
- **International Bilateral Agencies:** Funding, Advocacy, information and training

WITH ALL THE FIELD TRIALS, EFFICACY studies, acceptability tests and pilot runs proving successful, the time has now come to build up momentum on a global scale on the DFS strategy to tackle iron deficiency.

The ultimate aim is to provide access to DFS to 1.5 billion people in the 30 countries with the largest deficient populations.

As the table on anaemia burden in select countries shows, there's great potential for adopting DFS in many developing economies.

But since it will pose a programmatic challenge to venture into all 30 high burden countries at once, to begin with MI proposes to establish commercial production of DFS to cover 20 per cent of the population currently consuming iodised salt in five countries. The countries proposed are India, Indonesia, Bangladesh, Kenya and Nigeria, to hopefully reach 250 million people over an initial period of five years. Sri Lanka is another country poised to introduce DFS making use of the post-Tsunami opportunity, where salt iodisation infrastructure is being upgraded.

The geographic scope of activities is expected to expand as more countries show interest in introducing DFS.

In the five identified countries, the challenge before MI is to facilitate a broader adoption of DFS by salt producers and public distribution programs and to ensure that the supply of DFS premix does not lag behind the growing demand during this

EXAMPLES OF COUNTRY POTENTIAL FOR DOUBLE FORTIFIED SALT

Country	Anaemia prevalence in children <5 (%)	Anaemia prevalence in non-pregnant women 15-49 yrs (%)	Annual requirements of edible salt (metric tons)	Households consuming adequately iodised salt (%)	% of market reached by DFS quality and Medium quality salt
Asia					
Bangladesh	55.0	36.0	801,000	70.1	75
China	18.4	20.6	5,000,000	92.8	90
India	74.6	51.0	6,000,000	50.3	35
Sri Lanka	29.9	31.6	125,000	94	50
Indonesia	38.3	39.6	570,000	65.4	50
Myanmar	47.8	44.8	150,000	48.4	80
Nepal	64.9	62.1	160,000	62.6	25
Pakistan	56.3	58.5	850,000	17.0	25
Africa					
Kenya	60.0	42.5	95,000	90.6	95
Mozambique	70.6	53.8	56,000	62.0	28
Namibia	42.0	70.0	6,000	62.9	3
Nigeria	92.0	40.0	370,000	98.1	5
South Africa	36.9	26.3	130,000	62.4	90

sensitive period of technology adoption.

So, what are the possible strategies for scale up?

The success of the Universal Salt Iodisation program provides a few clues. For any mass campaign to be successful, it requires a buy-in from not just governments, but from one and all and a multi-sector concerted approach. For effective on-the-ground implementation *(see graphic below)*, a host of people need to get involved.

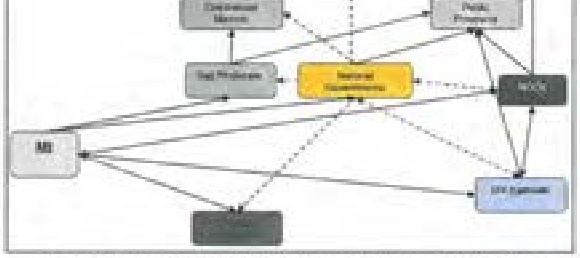
In the Iodine campaign, a major multi-sectoral collaboration led to significant impact in reducing IDD. National governments, salt companies, bodies such as UNICEF, Kiwanis International, MI and a range of international partners worked together to encourage industry worldwide to iodise all salt produced for human and animal consumption. A public investment of only US$ 400-million leveraged private investment of nearly US$ 1.5 billion over a 15-year period, resulting in expanded access to iodised salt of more than 70 per cent of the global population.

A similar multi-sectoral collaboration can, therefore, be expected to pay off in the case of tackling iron deficiency through DFS.

THE SALT PROCESSORS

First in the chain are obviously salt processors. Since most countries already practice iodine fortification, double fortification of salt can easily be introduced with minimum disruption to the existing practices and systems in place. This is one of the reasons why the DFS premix formulation selected by MI contains only encapsulated iron. The encapsulated iron premix can be readily added to iodised salt without changing local iodised salt production.

It is encouraging to note that increasing numbers of salt manufacturers are upgrading their facilities to produce higher quality salt, which, beyond increasing the commercial value of the salt, would make it suitable for double fortification. MI, in its salt iodisation support programs, is actively encouraging



Schematic representation of collaborative linkages with the public and private sector that will help take DFS to global scale

this 'modernisation' of salt manufacturing. The salt industry also has a major role to play in providing technical inputs, resources and marketing.

GOVERNMENT

Governments have a critical role to play in terms of advocacy, resources, program support and even implementation of poverty targeted programs. Creating a national policy and regulatory framework will pave the way for systematic implementation.

INTERNATIONAL BILATERAL AND MULTILATERAL AGENCIES

Wielding significant influence globally, and enjoying great bandwidth with governments, international bilateral and multilateral agencies are important players in public health campaigns around the world. From raising funds to advocacy to information and training, they can play an important role in scaling up campaigns to global levels.

LOCAL NGOs

Strong action at the grassroots is needed for the success of any public program. This is where local NGOs have a big role to play – in not just advocacy and creating awareness, but also in implementing and monitoring programs.

MI'S ROLE

Going beyond its initial role of technology transfer and policy advocacy, MI is now driving action through a series of collaborative efforts. MI envisages a catalytic role for itself in the DFS scale up efforts. One where it will be the nodal point in building linkages across governments, salt industry and implementing agencies. Among other things, MI intends to:

- Reach 250 million people over an initial period of five years with a particular focus on the most vulnerable, and secure sustainability thereafter on a commercial basis or through integration to health interventions for vulnerable populations
- Transfer technology for the production of DFS premix to developing countries
- Build the capacity of local salt processors to adequately fortify salt and to market DFS to vulnerable populations through commercial and public distribution channels
- Ensure adequate supply of DFS premix to emergency and school feeding programs around the world
- Catalyse the uptake and investments in scaling up national DFS supply in more countries
- Invest further in R&D to continously improve outcomes and scalability of program

CATALYSING CHANGE THROUGH COLLABORATIONS

MI's role in eliminating hidden hunger

PROMISE OF DFS
At the UN General Assembly in 2002, governments had pledged to reduce Iron Deficiency Anaemia in women and children by 1/3rd before 2010 and to contribute to reaching the Millennium Development Goals. Can DFS lead the way?

JUST AS DOUBLE FORTIFIED SALT IS A story of co-existence and collaboration (who would have, after all thought that Iron and Iodine could learn to live together), working to eliminate hidden hunger, or micronutrient deficiencies, is a story of successful partnerships.

The Canada-headquartered Micronutrient Initiative, which has offices in Asia and Africa, is a non-profit organisation that is dedicated to ensuring that the world's most vulnerable – especially women and children – in developing countries get the vitamins and minerals they need to survive and thrive.

MI not only develops, implements and monitors innovative, cost-effective and sustainable solutions for hidden hunger, it also often acts as a catalyst for change. It has driven action in many important child survival, child development and maternal health programs around the world.

For all of these complex programs, MI has used the partnership route to progress. MI believes in forging partnerships with governments, industry, local networks, stakeholders, and prefers the collaborative approach to eliminate hidden hunger.

In developing the DFS strategy, MI hopes to bring together and catalyse many players – be it the scientific community, the government, the industry, consumer organisations, the donors or the NGO bodies – into action. A start has been made, but many more collaborations are needed before the DFS project can pick up the scale and momentum of the iodisation program.

Also, DFS is but one tool in the ongoing battle against iron deficiency. A complementary approach using multiple tools will be the most effective strategy in tackling this serious global nutrition problem.

The larger vision for MI is to see a world free of hidden hunger – to realise this vision, partnerships across the world hold the key.

The Micronutrient Initiative is an international not-for-profit organization dedicated to ensuring that the world's most vulnerable – especially women and children – in developing countries get the vitamins and minerals they need to survive and thrive, through supplementation and food fortification programs. Its mission is to develop, implement and monitor innovative, cost effective and sustainable solutions for hidden hunger, in partnership with others. Headquartered in Ottawa, Canada, MI maintains regional offices in New Delhi, India and Dakar, Senegal and reaches people in more than 70 countries.

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