Terms of Reference for Iodine Stability in Salt Study in Pakistan

Background

Iodine Deficiency Disorder (IDD) is a public health problem in Pakistan, a country with more than half of the population estimated to be at risk for Iodine Deficiency Disorders as reflected in various surveys. Government of Pakistan initiated the National Iodine Deficiency Disorders (IDD) Control Program in the hilly areas of the country in 1989 when alarming figures related to prevalence of goitre and severe iodine deficiency were reported in the northern areas of Pakistan. The USI Program was revitalized in 2006 based on lessons learnt from the earlier phases of the USI program. The revitalized program was piloted in 20 districts by the then Nutrition Wing of Ministry of Health Pakistan with the assistance of development partners, Micronutrient Initiative, UNICEF and WFP and later scaled up in phases to 102 districts. The program resulted in significant improvements in the consumption of adequately iodized salt and the iodine status of the population. The National Nutrition Survey conducted in 2011 has recorded the household consumption of iodized salt as 69 percent compared to 17 percent in 2001. The increased consumption of iodized salt led to a decrease in the percentage of children 6-12 years of age with iodine deficiency by 28 percent (i.e. NNS 2011-36 percent: NNS 2001-64 percent). Prevalence of goiter amongst women of childbearing age also decreased to one third as per NNS of 2011 and now stands at only 3 percent.

Salt is iodized by the addition of fixed amount of potassium iodate as an aqueous solution at the production stage. In Pakistan, the law mandates salt for human consumption must have iodine levels of more than 30 ppm at the production level and 15 ppm or more at the consumer level. This gap of iodine content between the production and consumer end is to allow for losses of iodine which take place in transit and storage from the production of salt to its consumption at the household. Moisture is naturally present in the salt, or is absorbed from the air by hygroscopic impurities such as magnesium chloride. The pH of the condensed moisture on the salt is very much influenced by the type and quantity of impurities present and affects the stability of the iodine compound. Exposure to moisture correlates with the type and quality of packaging and sealing that has a direct bearing on iodine stability in the salt. Further high moisture content would dissolve the iodate and in extreme cases promote the migration of iodine to the bottom of the bag.

In recent years, there has been a significant improvement in the quality of salt being produced in the country as well as the packaging material being used. Large investments have been made to introduce new technology for production of high grade refined salt and better packaging. These improvements have a significant bearing on iodine losses in transit. There has also been a significant increase in the price of potassium iodate in the international markets which significantly increases the cost of iodization highlighting the need to minimize the use of iodate and cost.

In this context, there is a need to quantify the exact losses of iodine in the different types of salt in the typical environmental conditions of Pakistan. This will inform the policy on the optimal level of salt iodization that will ensure the recommended level of iodine intake by the population at the household level.

Considering these developments, an attempt is undertaken to evaluate the stability of iodine in iodized salt in different environmental condition, moisture content, relative humidity, packaging materials and other factors. The study report will be used as an evidence for the government in revising the iodine content at the production level.
Overall Objective

The overall objective of the study is to inform the policy on the optimal level of iodine at the production level in Pakistan by quantifying the losses of iodine in transit and storage from production to consumption at the household level.

Specific Objectives of the Study

- To measure the stability/loss of iodine in different types of salt
- To measure the stability/loss of iodine under different climatic conditions of Pakistan
- To measure the stability/loss of iodine in salt packed in different materials.

Review of earlier stability studies and methodologies

There have been a number of studies to estimate iodine stability of salt. Diosady, Mannar and Fitzerald (1998)¹ tested the stability of salt in an environmental chamber at the University of Toronto. The study tested 12 types of salt from different locations in two types of packaging material (Solid low density polythene bags and woven high density polythene bags) in two types of environmental conditions (40°C and 60% relative humidity; 40°C and 100% relative humidity). High humidity resulted in rapid loss of iodine ranging from 30% and 98% of the original iodine content. Solid LDPE protected iodine to a great extent and the losses were highest in woven high density polythene bags.

In a field based study in Kenya², the stability of iron and iodine in DFS and plain iodized salts in two climatic zones of Kenya was assessed. The samples were packed in typical commercial polythene bags, transported in typical distribution network and stored in the two climatic zones. The Iodine retention of 96% in Nairobi and 99% in a highland region was recorded after the end of 3 months.

In another study of iodine stability in salt³ in India, iodized refined salt and iodized ordinary salt was packed in LDPE salt pouches and further in HDPE bags and placed in closed containers to protect from light. These samples were transported by road and stored in three different climatic zones. The salt samples were stored in room conditions and tested for iodine and iron content after every month. It was observed that the iodine retention of the salt was over 96% at the end of 15 months.

A study in Philippines⁴ was carried out to provide evidence on the stability of iodine in local aged and fresh salt iodized at 100 ppm iodine and exposed to various market and storage conditions. Samples of salt in open heaps and repacked salt were exposed for 4 weeks, and salt packed in woven polypropylene bags was stored for 6 months. Results revealed that for all types of exposed salt, iodine levels were above 60 ppm after the end of the study (4 weeks). Within each salt type, losses were greater for open-heaps than for repacked salt. The greatest drop in moisture content

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occurred in the first week for most types of salt and exposure combinations. Moisture content was linearly correlated with iodine content. Iodine levels in stored salt remained above 60 ppm even after 6 months.

Based on the review of the previous stability studies, two broad types of methodologies are possible for the present study;

1. Laboratory based studies by placing salt in simulated conditions and
2. Field based studies by placing salt in real life environmental conditions.

The generalizability of findings from laboratory based studies for a large country like Pakistan with several climatic zones and significant seasonal variations may not be possible. The field based studies conducted so far have been for limited type of packaging and climatic conditions. There has also been no study examining the iodine stability in salts from Pakistan in the environmental conditions of Pakistan.

This study will assess iodine stability of salt by placing samples in real field conditions in the different climatic zones of Pakistan.

**Methodology for salt sample collection and storage**

In order to test the stability of iodine in different types of salts under different conditions known to affect the stability, the following variables have been taken into consideration in this study:

**Types of salt:** There are a wide variety of salts available in Pakistan. These different types of salt have different levels and types of impurities, which interact with the ambient moisture and influence the loss of iodine. Studies have also shown that the use of highly purified salt would improve the stability of iodine in most cases\(^5\) (Diosady, Mannar and Fitzgerald, 1998). However, the use of non-refined salts will continue to play an important role in the short term in many developing countries. In Pakistan the rock salt taken out from the famous mines of Khewra is of good quality with high percentage of NaCl and very little impurities, while the salt taken from the salt mines in KP is of pure quality with high percentages of impurities like Gypsum and magnesium.

This study will test iodine stability in the five major types of salt in Pakistan - Washed and dried lake salt, Refined lake salt, Good Quality Rock Salt (Punjab), Poor Quality Rock Salt with impurities (Khyber Pakhtoonkhwa, KP) and refined rock salt.

In order to measure iodine loss in salt with minimal impurities, analytical grade salt (close to 99.5% pure) will be placed in each climatic zone and retrieved at specified intervals.

**Type of Packaging:**

The type of packaging influences the level of protection offered to salt against a number of elements including moisture. Studies have shown that solid, non-woven polymer bags are the best protection against contacts with moisture and if properly sealed and kept intact will maintain the moisture level in the salt throughout the distribution system, thus minimizing the loss of iodine resulting from the absorption of moisture and the subsequent chemical reactions.

Salt Packaging materials in wide use in developing countries include paper, high- and low-density polyethylene, and woven bags made of jute, straw, or high-density polyethylene. Higher levels of iodine may need to be added to compensate for losses due the use of lower-grade packaging. In this

study, four types of packaging materials have been used namely; (i) HDPE, (ii) LDPE (iii) Laminated and (iv) HDPE packaging.

**Climatic Zones:** As discussed in the above sections, moisture plays a critical role in the stability of iodine. In salt stored in humid tropical conditions as in many developing countries like Pakistan, moisture absorbed by hygroscopic impurities contributes to rapid loss of iodine. Even pure salt (sodium chloride) will absorb moisture in an environment with relative humidity exceeding 74%. In order to assess the level of loss of iodine under different climatic conditions, the salt samples will be placed in appropriate rural conditions of the four climatic zones of Pakistan. Based on the geographic location and the physiographic factors, which modify precipitation and temperatures, the climate of Pakistan has been classified into 4 major climatic regions. These include (i) Marine Tropical Coastland, (ii) Sub Tropical Continental Lowlands, (iii) Sub-Tropical Continental Highlands and (iv) Sub Tropical Continental Plateau (Desert) (Sheikh and Hafeez, 1977) (see Annexure 1: Map showing the climatic zones of Pakistan).

It is proposed that salt will be stored in households of volunteer Lady Health Workers in the respective climatic zones.

**Time period:** Monitoring information and estimates from persons knowledgeable about the salt industry in Pakistan reveals that the time period from production of salt to consumption of salt is less than 6 months. Salt processors are distributed all over the country with some concentration around major cities and the two major salt mines. The consumers of salt of these processors are within the vicinity of the salt processors thereby resulting in the short time between production and consumption. Hence, the stability of iodine in salt is tested till 12 months (at intervals of 3 months each) keeping a buffer of few months of what a typical salt packet will remain in transit and storage.

**Weight of salt samples:** Most of the salt sold in Pakistan is in pack sizes of 800 grams. Hence, the salt samples will be kept in 800 gram packets. Some of the unrefined salts is also transported and stored in 40 kilogram sacks. Hence iodine stability of these unrefined salts stored in 40 kilogram sacks will also be tested.

**Sample Size and Sampling Design**

For the study, salt samples of 5 types of salt will be placed in 4 climatic zones of Pakistan with 800 gm packets and 40 kg bags stored in 3 types of packaging materials for a duration of 12 months. The total samples to be placed are as follows:

### Sample Matrix

<table>
<thead>
<tr>
<th>Type of salt</th>
<th>Type of packaging</th>
<th>No. of salt samples required for storage in 4 climatic zones for retrieval at 4 time points (3, 6, 9 and 12 months)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Washed and dried lake salt-800 gms packet</td>
<td>HDPE**</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td>LDPE**</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td>Laminated</td>
<td>16</td>
</tr>
<tr>
<td><strong>Sub Total</strong></td>
<td></td>
<td>48</td>
</tr>
<tr>
<td>Refined lake salt-800 gms packet</td>
<td>HDPE**</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td>LDPE**</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td>Laminated</td>
<td>16</td>
</tr>
<tr>
<td><strong>Sub Total</strong></td>
<td></td>
<td>48</td>
</tr>
<tr>
<td>Good Quality Rock Salt (Punjab)-800 gms packet</td>
<td>HDPE**</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td>LDPE**</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td>Laminated</td>
<td>16</td>
</tr>
<tr>
<td>Good Quality Rock Salt (Punjab)-40 kg bag</td>
<td>HDPE**</td>
<td>16</td>
</tr>
</tbody>
</table>
Preparation and storage of Salt Samples:

The samples by salt type and packaging will be centrally prepared at an initial concentration of 30 ± 2 ppm in 800 gms packets and 40 kg bags, labelled and sealed. Chemical analysis of the salt samples will be performed to determine their initial content of iodine, NaCl, Mg as chloride, Ca as sulphate, moisture and pH of 5% salt solution in water.

These samples will be transported to the different climatic zones and stored in typical household conditions. Four samples of each type will be stored in each climatic zone and one sample each will be retrieved at the end of 3, 6, 9 and 12 months of storage. Duplicate samples will also be stored in separate households in the climatic zone as a backup against replacement/theft or other exigencies where the integrity of the samples is compromised.

Measurement of temperature and humidity in the storage sites

In each of the storage sites, a thermo-hygrograph will be placed to measure the ambient temperature and humidity conditions for the duration of the study. For this purpose, four thermo-hygrographs/data loggers will be procured and installed in the four designated locations of the four climatic zones.

Retrieval of samples

The salt samples will be taken out after a period of 3, 6, 9 and 12 months and transported for testing in an identified laboratory and tested titration method as per the established protocol. The testing will include iodine and moisture content of the samples. In order to avoid variations in iodine content between the time of sampling and analysis, the testing will be performed within 15 days of retrieval of the sample.

The chemical analysis performed at the beginning of the study will also be repeated at the end of 12 months.

Constitution of a Technical Advisory Group

There will be an advocacy and technical advisory group (TAG) constituted with representation from the Government of Pakistan (MoNHSR&C), Provincial DoH, Scientific Community, Policy Makers, Influencers i.e. National Institute of Health (NIH), National Institute of Food Science and Technology (NIFSAT), Nuclear Institute of Food and Agriculture (NIFA), Focal Person for USI/IDD Project, Planning Commission, Salt Producer’s Representatives, The Network for Consumers Protection, GAIN, MI,
UNICEF, WFP, WHO and other relevant agencies. The TAG will review and guide methodology adopted by the study and also review progress and interim reports at appropriate time points.

**Deliverables**

The following deliverables are to be submitted in hard copy and electronic form by the firm/consultant as the implementation progresses to the Micronutrient Initiative:

- Preparation of salt samples, labeling and coding
- Transportation of salt samples to the climatic zones and retrieval for testing at the laboratory in Islamabad
- Cleaned and labeled datasets in SPSS / Excel format
- Interim reports at an interval of every 3 months
- Report of assessment finalized after review by MI
- Power point presentation summarizing the key findings

**Report Outline**

The selected agency/consultant will submit to MI a report which has the following sections/chapters:

1. Executive summary
2. Introduction
3. Study design
4. Findings of Iodine Stability by time
   - a. salt type
   - b. packaging
   - c. climatic zones
   - d. type and level of impurities
   - e. combination of the above variables
5. Conclusion and Recommendations

**Timeline**

The selected agency for this consultancy will adhere to the following timeline. The timeline is in reference to the time of signing the contract with MI. It is expected that period of consultancy will be 15 months and the final report will be finalized within this period.

<table>
<thead>
<tr>
<th></th>
<th>Months</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>1 2 3 4 5 6 7 8 9 10 11 12 13 14 15</td>
</tr>
<tr>
<td>Constitution of a research and logistics team and Preparation of study implementation plan</td>
<td></td>
</tr>
<tr>
<td>Preparation of salt samples, labelling and coding</td>
<td></td>
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<tr>
<td>Transportation of salt samples to different designated locations for storage</td>
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<tr>
<td>Retrieval of salt samples and transportation to the centralized laboratory</td>
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<tr>
<td>Testing and analysis of salt samples (including validation)</td>
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<tr>
<td>Data analysis and interim report writing</td>
<td></td>
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<tr>
<td>Final Report writing and Dissemination</td>
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</table>
Annexure 1 : Map of Climatic Zones in Pakistan