Development of salt double fortified with iodine and iron for the prevention and cure of micronutrient deficiency diseases

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INTRODUCTION
Micronutrient deficiency diseases adversely affect the health of some 2 billion people, mostly in the developing world. Deficiencies of iodine, iron and vitamin A have devastating effects. The Copenhagen Consensus in 2008 listed iron fortification among the 3 most important problems in development. While micronutrients are inexpensive, their delivery is often thwarted by technological, social and economic problems. As salt is universally consumed, the simultaneous delivery of iron, iodine and other micronutrients through salt promises to be an effective solution. The objective of the research program was to develop an effective, safe and economical process that prevents iron-iodine interactions that previously resulted in catastrophic losses of iodine. Microencapsulation of either the iron or the iodine containing compound can provide a physical barrier to the migration and redox reaction of iron and iodine in the presence of moisture on salt. In this program we have developed, scaled-up and tested two successful approaches to the production of salt double fortified with iodine and iron.

MATERIALS & METHODS
With the support of the Micronutrient Initiative we developed a fluidized-bed based agglomeration and microencapsulation technique for producing a ferrous fumarate premix, that can be blended into iodized salt at a 1:150 ratio to provide one third of the daily iron requirement. Ferrous fumarate was selected over ferrous sulphate and ferric pyrophosphate due to its high bioavailability and bland taste. However, ferrous fumarate is dark red in colour, and would be noticeable to the consumer, when blended into salt. Accordingly, we developed a coating process, that masks the colour of ferrous fumarate. We tested the stability of the double fortified salt (DFS) at high temperature and humidity, both in the laboratory and the field. We scaled the process, and developed QC/QA techniques suitable for untrained operators. The iron premix technology was upgraded to reduce technological complexity, capital requirements and operating costs.

RESULTS & DISCUSSION
While iodized salt double fortified with ferrous fumarate lost all iodine within two months, fortification with ferrous fumarate microencapsulated in soy stearine resulted in DFS stable for a period of a year. To prevent segregation, the ferrous fumarate was agglomerated to the particle size of table salt, 300-600µm using a Wurster-type fluidized bed apparatus. The dark red colour of the fumarate was masked by titanium dioxide, resulting in DFS that was indistinguishable from iodized salt in terms of both appearance and taste. The agglomeration process produced particles that formed an aggregation of small spherical particles, thus having irregular shapes with many void spaces. This required up to 40% by weight of stearine (fully hydrogenated soy oil) to form well-protected iron premix particles. We observed minimal
iodine losses when DFS was stored at elevated temperatures (40°C) and humidity (>60%). We prepared typical commercial packs of 30 bags each containing 200g salt, and equipped the packs with temperature and humidity monitors. The packs were distributed through normal commercial channels in hot, both arid and wet regions of Kenya and Nigeria. The DFS samples were retrieved and returned to Toronto for analysis. The optimal formulations had similar iodine losses to that observed in iodized salt controls, while iodized salt with unencapsulated ferrous fumarate lost essentially all of its added iodine. The high stearine content resulted in low density in the iron premix particles, which could lead to the premix particles floating and being discarded if the salt is washed in cold water. As fluidized bed agglomeration requires expensive equipment that is not widely available in developing countries, we developed an alternative approach to the agglomeration of ferrous fumarate. Cold extrusion using high-gluten wheat flour as a binder resulted in regular cylinder shaped particles, 0.4mm in length and diameter. As these particle were densely packed, they required reduced levels of titanium dioxide for surface coverage, and only 20% stearine for film coating. As illustrated in Figure 1, the fluidized bed agglomerated particles are irregularly shaped, while the extruded premix is in the form of regular cylinders, matching the size of the irregularly shaped salt.

The extruded particles had densities of 1.8-1.95, compared with 0.85-97 for the fluidized bed agglomerated ferrous fumarate. In a field trial in Southern India with 3.4 million children, funded and coordinated by the Micronutrient Initiative, replacing the salt used in cooking their school lunch with DFS reduced the number of anemic children by some 1 million in eight months [1].

CONCLUSION

It is clear that salt is a suitable carrier for both iodine and iron, and is an effective weapon in the prevention of iodine deficiency disorders and anemia.

REFERENCES