A Tool to Critically Test "Good" Ideas in Fortification of Edible Products

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An anecdote

A 10 gram “marvelous” invention that is going to supply 50% of all nutrient requirements.

Micronutrient Powders

A blend of fortificants (sources of micronutrients) in powder form to be added to foods prior to consumption in order to supply significant amounts of micronutrients

(Home-fortification or fortification at the point of consumption)

Are these innovative?

What have we done with iodized salt since 1922-24?

Is iodized salt a food or a supplement?

- A 5 g/d salt intake supplies 119% of Estimated Average Requirements (EAR) of iodine to WRE when the iodine content is 30 mg/kg
- Potassium iodate (fortificant) as the source of iodine (nutrient) is present in 1 part per 19,667 parts of salt [i.e. it could be added by spraying]
- The fortificant cost is $1.46/MT, i.e. 3% price*, or $0.0027/year per person

* Assuming a salt price of US$0.05/kg

Why is iron not added ?

Why is it difficult to add iron?

- A 5 g/d salt intake, with an iron content of **2,000 mg/kg** using micronized ferric pyrophosphate as the iron source, would supply 26% of EAR of iron to WRE in a 5% iron-bioavailable diet.
- This translates to1 part of iron fortificant per 125 parts of salt [i.e. 157 times more than iodate; therefore it should be done in an enclosed blender]
- The fortificant cost is $99.36/MT, or 199% price of salt, or $0.1813/year per person [i.e. 68 times > iodine]

  [but see above that it is only supplying 26% EAR]

But… you are so negative… because

Efficacy trials have shown improvement of iron status

Experimental Design*:

- India; 18 villages; no-malaria endemic areas; diet poor in animal products, and based on rice or finger miller and vegetable sauce (lentils, vegetables, species)-10% bioav.
- Children 12 years old, and who were iron deficient according to iron-status biomarkers.
- Micr. ferric pyroph.-2.5 µm (25% iron) or encapsulated ferrous fumarate (15% iron) at 2,000 mg Fe/kg in IS.
- Daily salt intake: **11.3**±5.1 g/d per family member; **8.3** ±3.8 g/d per children.
- Assessment of changes in hemoglobin, ferritin, serum transferring receptors; CRP as the acute phase protein.

Am J Clin Nutr 2008; **88**:1378-87.

Results of the efficacy trial (10 months):

Parameter	Control	Micr.Ferr.Pyroph.[b]	Encap. FF[c]
Age (years)	11.2 $\pm$ 2.9	11.7 $\pm$ 2.8	11.6 $\pm$ 2.8
Anemic children (%)	19.2 $\rightarrow$ 14.5	16.8 $\rightarrow$ 7.7*	15.1 $\rightarrow$ 9.0**
IDA (%)	16.9 $\rightarrow$ 15.2	15.2 $\rightarrow$ 6.4*	11.7 $\rightarrow$ 3.8**
Iron deficiency[a] (%)	68.2 $\rightarrow$ 68.0	56.6 $\rightarrow$ 32.8***	52.4 $\rightarrow$ 34.6**

[a] SF < 15 µg/L or TfR > 7.6 mg/L plus ZnPP > 40 µmol/mol heme; excluding children with high CRP
[b] Iodine stability was reduced in salt with 1.8% moisture
[c] 17% households stopped using EFF salt because changes in color in the food, but use resumed after explanation of the benefits of this type of salt
* *P* < 0.05, ** P < 0.01, *** P < 0.001

Why the impact?

Additional iron intake	**Control**	**Experimental groups**
Absolute (mg/d)	0	16.6 mg/d
EAR (%)	0	160 %

How the % EAR would change if:

Condition	Expected change as % EAR
1. Salt consumption of 4 g/d instead of 8 g/d	1/2
2. Iron content in salt reduced from 2,000 to 1,000 mg/kg	1/2
3. Diet based on corn or other whole cereals	1/2
4. WRE are assessed instead of 12 year old children	1/2
5. A combination of all of the above	**1/16 !!!**
6. Deliver the same type and amount of iron through rice or other edible vehicles	**SAME !!!**

Conclusion: Impact is due to the additional iron intake (nutrient) and it has nothing to do with the salt (carrier) !!!

The Food Fortification Formulator (FFF)

A computational program in Excel with the purpose of determining potential additional micronutrient intakes, cost, premix formulation, and standards (8 common carriers).

- Inputs: Estimated intake of the vehicle (desirable by age group); customary price of the vehicle; and some idea of mineral bioavailability in the diet.
- Outputs: Estimated additional intake (absolute, %EAR, %RNI) for age- and gender- groups; expected nutrient levels at factories and retail stores; possible premix formulation; approximated overall cost and per nutrient; cost per consumer.
- Modifiable parameters: Reference values of EAR and RNI; stability of micronutrients in vehicles; price of fortificants; variation of micronutrient levels in the vehicle; intrinsic content of micronutrient in vehicle.

Example of FFF final output (a)

I-2 SALT FORTIFICATION FORMULATOR (10-08-21) with Summary [Compatibility Mode] - Microsoft Excel

Analysis of Fortification Formulation of Salt for Females 19-50

USING THE DRY METHOD (MIXING MICRONUTRIENT PREMIX WITH UNFORTIFIE

COUNTRY:	**Dream Land**			**FOOD:**	**Salt**		
Adjusted Population Mean of the Food Intake[1] =	**5.0**	**g/day**	**Cost per consumer =**	**$0.322**	**US$/year**	**Fortification cost[2] =**	**$176.59** US$/MT
P-50 Food Intake of target group =	**5.0**	**g/day**	**Increase product price =**	**294.32%**		**Premix cost =**	**$13.24** US$/kg

NUTRITIONAL ESTIMATIONS				**FOOD CONTROL PARAMETERS (mg/kg)**						
NUTRIENT	**Additional Daily Intake[3]**			**Level of Addition**	**Production Parameters**			**Regulatory Parameters**		**Fort com**
	(mg/day)	(% EAR/day)	(% RNI/day)	Average	minimum	average	maximum	Minimum Legal	Maximum Tolerable	
Vit. A	0.175	49%	35%	**50.0**	27.6	50.0	72.4	19.3	72.4	Vit. A Paln
Iron (Micronized ferric pyrophosphate)[a]	10.000	26%	12%	**2000**	1104.000	2000.000	2896.000	1104.000	2896.000	Micron pyrop
Iodine (Iodate)	0.128	119%	85%	**30**	22.3	30.0	37.7	20.1	37.7	Potass
Iodine (Iodide)	0.000	0%	0%	**0**	0.000	0.000	0.000	0.000	0.000	Potassium i
Fluoride (Sodium)	0.000	0%	0%	**0**	0.000	0.000	0.000	0.000	0.000	Sodium fl m
Fluoride (Potassium)	0.000	0%	0%	**0**	0.0	0.0	0.0	0.0	0.0	Potassium m
										+ otl

Notes:

[1] It is the per capita intake divided by the proportion of the population that consumes the food.

[2] It assumes that the cost of the addition of the premix is 90% of the total cost of the fortification process.

[3] These values are calculated taking in consideration the micronutrient losses during storage and distribution, as well as during cooking.

[a] Sometimes the analytical method allows to identify only the added iron from the fortificant. In this case

INTRO | SUMMARY | INPUTS | A. Selecting Levels | B. Fortification Parameters | C. Premix Formulation | D. Food Intake | Technical Information

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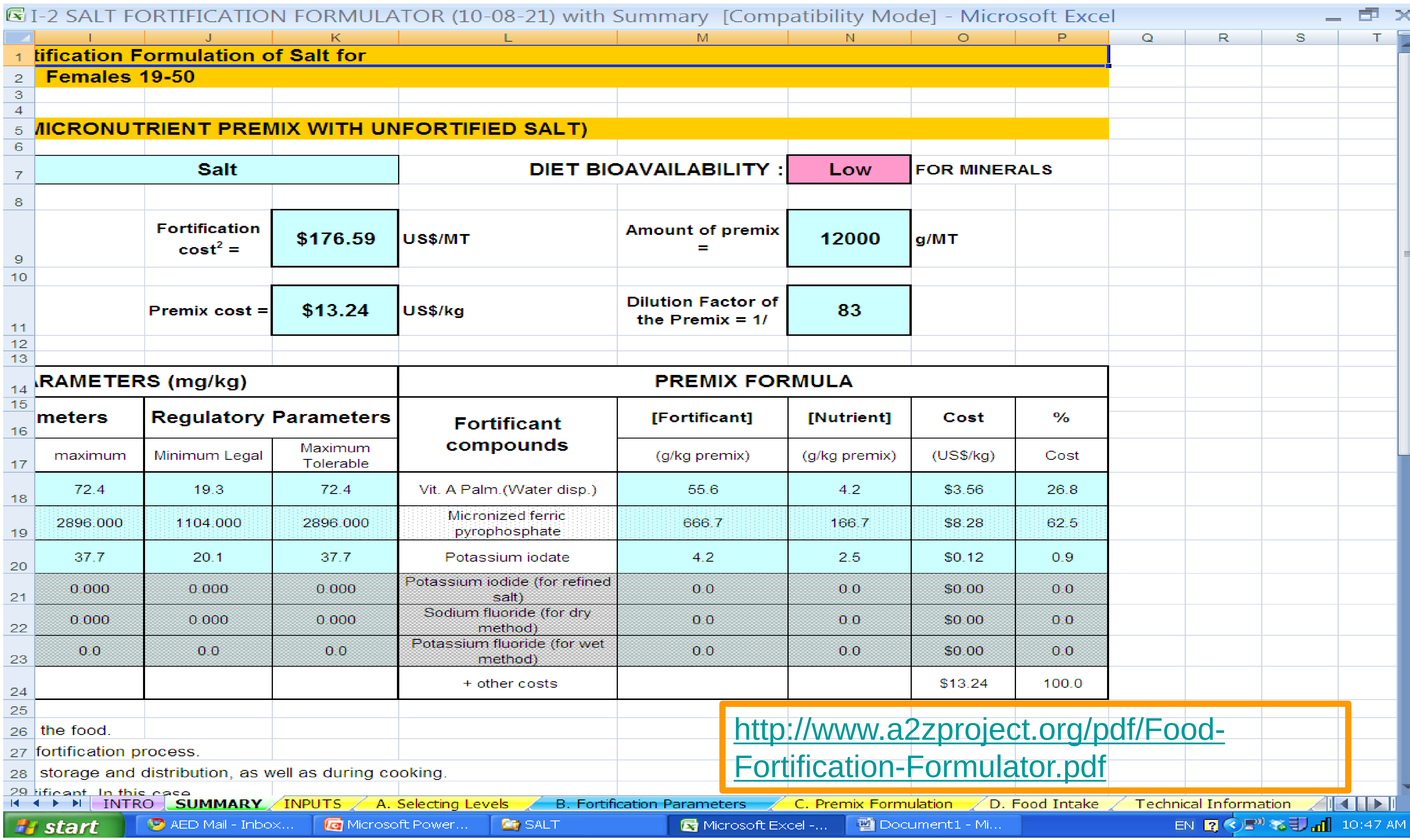
Example of FFF final output (b)



I-2 SALT FORTIFICATION FORMULATOR (10-08-21) with Summary [Compatibility Mode] - Microsoft Excel

tification Formulation of Salt for
Females 19-50

MICRONUTRIENT PREMIX WITH UNFORTIFIED SALT)

Salt		DIET BIOAVAILABILITY :	Low	FOR MINERALS		
Fortification cost[2] =	$176.59	US$/MT	Amount of premix =	12000	g/MT	
Premix cost =	$13.24	US$/kg	Dilution Factor of the Premix = 1/	83		

RAMETERS (mg/kg)			PREMIX FORMULA				
meters	Regulatory Parameters		Fortificant compounds	[Fortificant]	[Nutrient]	Cost	%
maximum	Minimum Legal	Maximum Tolerable		(g/kg premix)	(g/kg premix)	(US$/kg)	Cost
72.4	19.3	72.4	Vit. A Palm.(Water disp.)	55.6	4.2	$3.56	26.8
2896.000	1104.000	2896.000	Micronized ferric pyrophosphate	666.7	166.7	$8.28	62.5
37.7	20.1	37.7	Potassium iodate	4.2	2.5	$0.12	0.9
0.000	0.000	0.000	Potassium iodide (for refined salt)	0.0	0.0	$0.00	0.0
0.000	0.000	0.000	Sodium fluoride (for dry method)	0.0	0.0	$0.00	0.0
0.0	0.0	0.0	Potassium fluoride (for wet method)	0.0	0.0	$0.00	0.0
			+ other costs			$13.24	100.0

the food.
fortification process.
storage and distribution, as well as during cooking.

http://www.a2zproject.org/pdf/Food-Fortification-Formulator.pdf

Conclusion

"Good" ideas deserve critical analysis and maturation to produce innovative results. Otherwise, they may end up as merely good intentions, unfounded claims, and wasteful use of resources, time, and hope.