COMBATING MICRONUTRIENT MALNUTRITION IN AFRICA WITH FLOUR FORTIFICATION: CURRENT STATUS AND CHALLENGES

Filip Van Bockstaele, 15-12-2017, GAPSYM11
RATIONAL

- Vitamins and minerals = micro-nutrients
  - Low presence in foods
  - Play an essential role in biochemical reactions in human body
- Deficiencies in micronutrients
  - Often related to malnutrition
  - Cause diseases, birth defects, reduced immunity, reduced growth and cognitive development
# RATIONALE

## Levels of deficiencies around the world

<table>
<thead>
<tr>
<th>Country</th>
<th>Neural tube defects per 10,000 births</th>
<th>% Anemia in non-pregnant women of reproductive age</th>
<th>% Anemia in pre-school children</th>
<th>% Population at risk of inadequate zinc intake</th>
</tr>
</thead>
<tbody>
<tr>
<td>Afghanistan</td>
<td>20</td>
<td>31</td>
<td>44</td>
<td>20.2</td>
</tr>
<tr>
<td>Belgium</td>
<td>9</td>
<td>18</td>
<td>13</td>
<td>6.8</td>
</tr>
<tr>
<td>Uganda</td>
<td>13</td>
<td>26</td>
<td>56</td>
<td>20.5</td>
</tr>
<tr>
<td>Zimbabwe</td>
<td>23</td>
<td>28</td>
<td>59</td>
<td>48.4</td>
</tr>
<tr>
<td>South-Africa</td>
<td>23</td>
<td>27</td>
<td>41</td>
<td>20.0</td>
</tr>
<tr>
<td>USA</td>
<td>4.6</td>
<td>12</td>
<td>6</td>
<td>5.0</td>
</tr>
<tr>
<td>Tanzania</td>
<td>13</td>
<td>38</td>
<td>61</td>
<td>34.1</td>
</tr>
<tr>
<td>DR Congo</td>
<td>20</td>
<td>49</td>
<td>67</td>
<td>54.3</td>
</tr>
<tr>
<td>Brazil</td>
<td>38</td>
<td>19</td>
<td>24</td>
<td>7.3</td>
</tr>
</tbody>
</table>

The World Health Organization (WHO) estimates that more than 2 billion people are deficient in key vitamins and minerals, particularly vitamin A, iodine, iron and zinc.

<table>
<thead>
<tr>
<th>Solution</th>
<th>Challenge</th>
</tr>
</thead>
<tbody>
<tr>
<td>Micronutrient supplements for children (A &amp; Zn)</td>
<td>Malnutrition</td>
</tr>
<tr>
<td>The Doha development agenda</td>
<td>Trade</td>
</tr>
<tr>
<td>Microwave nutrient fortification</td>
<td>Malnutrition</td>
</tr>
<tr>
<td>Expanded immunization coverage for children</td>
<td>Diseases</td>
</tr>
<tr>
<td>Biofortification</td>
<td>Malnutrition</td>
</tr>
<tr>
<td>Deworming, other nutrition programs in school</td>
<td>Malnutrition</td>
</tr>
<tr>
<td>Lowering the price of schooling</td>
<td>Education</td>
</tr>
<tr>
<td>Increase and improve girl’s schooling</td>
<td>Women</td>
</tr>
<tr>
<td>Community-based nutrition programs</td>
<td>Malnutrition</td>
</tr>
</tbody>
</table>

Nobel Prizewinning Economists: Finn Kydland, Robert Mundell, Douglass North, Thomas Schelling, Vernon L. Smith
Food fortification has been defined as the addition of one or more essential nutrients to a food, whether or not it is normally contained in the food, for the purpose of preventing or correcting a demonstrated deficiency of one or more nutrients in the population or specific population groups (FAO/WHO 1994).
WHY FOOD FORTIFICATION?

– It works!

Significant reduction in deficiencies when fortifying with iron, folate and iodine

*(Das et al. Micronutrient fortification of food and its impact on woman and child health. Systematic Reviews, 2013, 2:67)*

– Cost efficient:

1:12 Chile
1:30 South Africa
1:48 United States

FOOD FORTIFICATION VEHICLES

OIL
Vitamin A, E

MILK
Vitamin A, D
Ca

CEREALS
Fe, Zn
Vit. B1, B2, B3, B6
Folic acid
Vitamin A

SALT
Iodine

SUGAR
Vitamin A
CEREALS IN THE WORLD

– Annual production of major cereals in 2010/2014

(source: faostat.fao.org)

<table>
<thead>
<tr>
<th>Cereal</th>
<th>2010</th>
<th>2014</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn</td>
<td>844</td>
<td>1021</td>
</tr>
<tr>
<td>Rice (paddy)</td>
<td>672</td>
<td>741</td>
</tr>
<tr>
<td>Wheat</td>
<td>651</td>
<td>728</td>
</tr>
<tr>
<td>Barley</td>
<td>123</td>
<td>144</td>
</tr>
<tr>
<td>Sorghum</td>
<td>56</td>
<td>68</td>
</tr>
<tr>
<td>Millet</td>
<td>29</td>
<td>28</td>
</tr>
<tr>
<td>Triticale</td>
<td>13</td>
<td>17</td>
</tr>
<tr>
<td>Rye</td>
<td>12</td>
<td>15</td>
</tr>
<tr>
<td>Buckwheat</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>
GRAIN FORTIFICATION WORLDWIDE

Wheat flour – 66 countries

Rice – 1 country (Papua New Guinea)

Wheat flour and maize flour – 14 countries

Wheat flour and rice – 3 countries (Nicaragua, Panama, Philippines)

Wheat flour, maize flour, and rice – 2 countries (Costa Rica and the United States)

No grain fortification legislation

* Legislation has effect of mandating grain fortification with at least iron or folic acid. Legislation status from the Food Fortification Initiative (www.FFInetwork.org) May 2016
HOW ARE CEREALS FORTIFIED?

1. Coating/dusting
2. Micronutrient kernels

- Bran
- Fine white flour
- Powder micronutrient premix
- Maize meal
- Paddy rice
- Polished rice
HOW ARE CEREALS FORTIFIED?

- Flour fortification @ industry

![Diagram of flour fortification process]

- Premix Feeder
- Mixing Conveyor
- Flour In ≠ streams
- Flour Out
- Packaging
FLOUR FORTIFICATION IN AFRICA: PROGRESS
Mandatory fortification: Country has legislation to mandate fortification of wheat flour and/or maize flour (27 countries in May 2016)

Voluntary fortification: At least 50% of the industrially milled wheat or maize flour is fortified through voluntary efforts (5 countries in May 2016)
FORTIFICATION: CHALLENGES

- Fortification operation: relatively easy
- Setting up national fortification programmes: challenge!

Legislation
Technical standards
Inspection/control
Information

Quality assurance
Quality control (fast methods)
Premix/feeder technology

Are products accepted
Are products bought?
Are products consumed?
Micronutrient status?

=> Continuous monitoring system needed!
SUPPORTING FORTIFICATION IN AFRICA

- Partnership since 2008

- Aim: improve health in Africa through the enrichment of wheat and maize flour with essential vitamins and minerals

- www.smarterfutures.net
SMARTER FUTURES

– Supporting fortification efforts:
  – Development of **tools**:
    – Fortimas monitoring system
    – Cost benefit tool
    – Millers toolkit
  – Organising **trainings** and meetings
    – QA/QC of flour fortification
    – Country trainings on tools

Capacity building
  Knowledge transfer
  Connecting stakeholders
  ⇒ Government
  ⇒ Millers
Knowledge transfer:
- cereal processing
- fortification technology
- legislation & standards
- monitoring
- quality control

Field visits:
- Maize flour mill
- Government analytical lab

Discussion groups:
- Profession groups
- Country teams

=> Developing strategy for fortification
Makerere University  
Kampala, Uganda, May 2016  
Regional training

Stakeholders: millers, government and academia: 79 participants (incl. facilitators)  
-> 20 student/lecturers from 7 countries: Uganda, Burundi, Rwanda, South-Sudan, Kenya, Tanzania, Mozambique

14 scholarships sponsored by VLIR-UOS (Belgium): Short training initiative (STI)
CHALLENGES: MAIZE
MAIZE FLOUR FORTIFICATION

Maize availability and Fortification Legislation

- **Mandatory fortification legislation**
- **Voluntary legislation**
- **No availability or legislation data**
- **75 or more grams available per person per day**
- **Less than 75 grams available per person per day**
Dar es Salaam, Tanzania
Maize strategy meeting

Stakeholders: millers, government involved from maize producing and consuming countries: 71 participants (incl. facilitators)

Knowledge: maize processing structure overview throughout Africa

Maize fortification technology + field trips to maize mills (large and small)

Declaration of Dar on maize fortification
SMALL SCALE HAMMER MILLS

->1 step size-reduction of dehulled maize
SMALL SCALE HAMMER MILLS

– Fortifiable?
CHALLENGES:
SOUTH AFRICA STORY
FOOD FORTIFICATION BECOMES A REALITY IN SOUTH AFRICA

On 7 April 2003 regulations pertaining to the mandatory fortification of all maize meal and wheat flour were printed in the Government Gazette. Published under Act No 54 of 1972, Foodstuffs, Cosmetics and Disinfectants. These regulations will become legally applicable and implementable 6 months later, on 7 October 2003.

The regulations apply to any person or company which manufactures, imports, or sells maize meal and wheat flour, and foodstuffs which contain 90% of either maize meal or wheat flour such as bread.

The fortification cocktail and addition rates were scientifically calculated based on the research and data from the SAWACC Study as well as the South African National Food Consumption Survey concluded in 2000. Tables I and II list the Fortification Standards for wheat flour and bread, and maize meal respectively.

An official fortification logo (monochromatic or in colour) with an allowed health claim has been developed which may be used voluntarily on the packaging and advertising materials of fortified maize meal and wheat flour.

**TABLE I. FORTIFICATION STANDARDS – WHEAT FLOUR AND BREAD**

<table>
<thead>
<tr>
<th>Micronutrient</th>
<th>Unit</th>
<th>Wheat Flour</th>
<th>Wheat Bread</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vitamin A</td>
<td>µgRE/kg</td>
<td>1610</td>
<td>1415</td>
</tr>
<tr>
<td>Thiamine</td>
<td>mg/kg</td>
<td>3.91</td>
<td>3.79</td>
</tr>
<tr>
<td>Riboflavin</td>
<td>mg/kg</td>
<td>2.05</td>
<td>1.95</td>
</tr>
<tr>
<td>Niacin</td>
<td>mg/kg</td>
<td>38.42</td>
<td>54.76</td>
</tr>
<tr>
<td>Pyridoxine</td>
<td>mg/kg</td>
<td>2.82</td>
<td>3.07</td>
</tr>
<tr>
<td>Folacin</td>
<td>mg/kg</td>
<td>1.36</td>
<td>1.24</td>
</tr>
<tr>
<td>Iron</td>
<td>mg/kg</td>
<td>43.65</td>
<td>47.97</td>
</tr>
<tr>
<td>Zinc</td>
<td>mg/kg</td>
<td>20.70</td>
<td>26.73</td>
</tr>
</tbody>
</table>

1 Retinol equivalents (RE) = 1 µg retinol = 3.33 IU (International units) vitamin A.

**TABLE II. FORTIFICATION STANDARDS – MAIZE MEAL**

<table>
<thead>
<tr>
<th>Micronutrient</th>
<th>Unit</th>
<th>Super</th>
<th>Special</th>
<th>Sifted</th>
<th>Unsifted</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vitamin A</td>
<td>µgRE/kg</td>
<td>1877</td>
<td>1877</td>
<td>1877</td>
<td>1877</td>
</tr>
<tr>
<td>Thiamine</td>
<td>mg/kg</td>
<td>3.09</td>
<td>3.86</td>
<td>4.76</td>
<td>5.57</td>
</tr>
<tr>
<td>Riboflavin</td>
<td>mg/kg</td>
<td>1.79</td>
<td>1.88</td>
<td>1.97</td>
<td>2.06</td>
</tr>
<tr>
<td>Niacin</td>
<td>mg/kg</td>
<td>29.70</td>
<td>31.86</td>
<td>34.65</td>
<td>38.25</td>
</tr>
<tr>
<td>Pyridoxine</td>
<td>mg/kg</td>
<td>3.89</td>
<td>4.25</td>
<td>4.79</td>
<td>5.42</td>
</tr>
<tr>
<td>Folacin</td>
<td>mg/kg</td>
<td>1.89</td>
<td>1.90</td>
<td>1.92</td>
<td>1.94</td>
</tr>
<tr>
<td>Iron</td>
<td>mg/kg</td>
<td>32.35</td>
<td>40.14</td>
<td>44.28</td>
<td>50.40</td>
</tr>
<tr>
<td>Zinc</td>
<td>mg/kg</td>
<td>18.90</td>
<td>22.55</td>
<td>26.60</td>
<td>30.20</td>
</tr>
</tbody>
</table>

1 Retinol equivalents (RE) = 1 µg retinol = 3.33 IU (International units) vitamin A.

*Where special permission was granted in terms of regulation 11, a lower iron content of 34.65 mg/kg is allowed.*

Revision of regulations since 2015

Food fortification working group
IDENTIFIED SHORTCOMINGS

- Bread vs cake flour

- Applied nutrients:
  - Fe: electrolytic Fe (40 ppm): shift to NaFeEDTA (15ppm Fe)
  - Zn: too low concentration: 15 -> 30 ppm (WHO)
CONDITIONS OF A SUCCESSFUL NATIONAL FORTIFICATION PROGRAM

- *Political support
- *Industry support
- *Consumer acceptance
- Mandatory legislation
- National implementation
- No cultural or other objection
- Availability of micronutrient premix
- Low cost economically sustainable

* Requires a private-public-civic partnership

No organoleptic changes of the cooked product
## Problem Statement

Factors that may limit the amount of fortificants that can be added to a single food vehicle

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Technological/sensory</th>
<th>Safety</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vitamin A</td>
<td>X</td>
<td>XXX</td>
<td>XXXa</td>
</tr>
<tr>
<td>Vitamin D</td>
<td>–</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Vitamin E</td>
<td>–</td>
<td>X</td>
<td>XXX</td>
</tr>
<tr>
<td>Vitamin C</td>
<td>XX</td>
<td>X</td>
<td>XXXc</td>
</tr>
<tr>
<td>Thiamine (vitamin B₁)</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Riboflavin (vitamin B₂)</td>
<td>XX</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Niacin (vitamin B₃)</td>
<td>–</td>
<td>XXXc</td>
<td>X</td>
</tr>
<tr>
<td>Vitamin B₆</td>
<td>–</td>
<td>X</td>
<td>–</td>
</tr>
<tr>
<td>Folic acid</td>
<td>–</td>
<td>XXX</td>
<td>–</td>
</tr>
<tr>
<td>Vitamin B₁₂</td>
<td>–</td>
<td>XXX</td>
<td>X</td>
</tr>
<tr>
<td>Iron</td>
<td>XXX</td>
<td>XX</td>
<td>X</td>
</tr>
<tr>
<td>Zinc</td>
<td>XX</td>
<td>XXX</td>
<td>X</td>
</tr>
<tr>
<td>Calcium</td>
<td>X</td>
<td>XX</td>
<td>XXXd</td>
</tr>
<tr>
<td>Selenium</td>
<td>–</td>
<td>X</td>
<td>–</td>
</tr>
<tr>
<td>Iodine</td>
<td>X</td>
<td>XXX</td>
<td>–</td>
</tr>
</tbody>
</table>

- no constraint; X, a minor constraint; XX, moderate constraint; XXX, major constraint.
- If an oil-based form is used to fortify oils or fats, costs can be reduced.
- Cost constraints are mainly a consequence of losses during manufacturing, storage, distribution and cooking which mean that a considerable overage is required.
- Much less of a concern if niacinamide, as opposed to nicotinic acid, is used as the fortificant.
- The risk of adverse effects is minimized by the co-addition of vitamin B₁₂.
- Refers to the more bioavailable forms.
- Cost constraints are mainly a consequence of the need to add such large amounts.
PORRIDGE PRODUCTION

Ingredients
- Water
- Maize
- Salt

Processing
- Water/maize ratio
- Water quality
- Stirring
- Cooking time
- Cooking pot

End Product
<table>
<thead>
<tr>
<th>Country</th>
<th>Maize Porridge is Called</th>
<th>Other Names</th>
</tr>
</thead>
<tbody>
<tr>
<td>Namibia</td>
<td>Oshithima</td>
<td>Nshima</td>
</tr>
<tr>
<td>Malawi</td>
<td>Thick</td>
<td>Umutshema</td>
</tr>
<tr>
<td>Zambia</td>
<td>Akoume</td>
<td>Bokora</td>
</tr>
<tr>
<td>Zimbabwe</td>
<td>Ugali</td>
<td>Ugali</td>
</tr>
<tr>
<td>Tanzania</td>
<td>Pap</td>
<td>Papu</td>
</tr>
<tr>
<td>South Africa</td>
<td>Pitu</td>
<td>Pitu</td>
</tr>
<tr>
<td>Kenya</td>
<td>Ugali</td>
<td>Ugali</td>
</tr>
</tbody>
</table>
IMPACT OF FORTIFICATION ON MAIZE PORRIDGE

– Impact of different iron sources on maize meal functionality (Master thesis Lien Bierens)

‘Pap’
IMPACT OF FE-SOURCE ON MAIZE PORRIDGE
IMPACT OF NAFE-EDTA ON MAIZE PORRIDGE
SENSORY TRIAL AT MAIZE FORTIFICATION MEETING, DAR ES SALAAM, TANZANIA

- Q1: Do any of these samples differ? If yes, which one?
- Q2: Which one did you like most?
- Q3: Why?

Around 1/3 of the participants indicated no difference among the samples was present. Of the other 2/3, preference to fortified/unfortified was 50:50
QUIZ: WHICH ONE IS FORTIFIED?
CHALLENGES: QUALITY CONTROL
QUALITY CONTROL

- Lack of in country quantitative methods: AAS, ICP
- Fast measuring techniques for fortificants: Fe, VitA, I

- Fully prepared reagent vials
- Off-line
- No expensive lab equipment needed
- Standardized protocols
- Quantitative
- Flour fortification = easy
- Africa made huge progress since 2004
- Challenges
  - Programs need monitoring and revision
  - Maize meal fortification needs attention
    - -> focus on small scale mills
  - Fast and reliable methods for quality control
ACKNOWLEDGEMENTS

- Research Group Cereal and Feed Technology
  Lien Bierens, Nele Vandevelde, Tom Hellemans

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  Anna Verster, Lieven Bauwens, Margo Vandenbroucke, Quentin
  Johnson, Philip Randall, Ronald Afidra, …

- VLIR-UOS
  - STI 2016
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Filip Van Bockstaele Ph.D

Research Group Cereal and Feed Technology

E  filip.vanbockstaele@ugent.be
T  +32 9 243 24 94
M  +32 498 24 44 63

www.ugent.be