MAIZE MEAL FORTIFICATION
AND ITS IMPACT ON MAIZE
PORRIDGE QUALITY

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FOOD FORTIFICATION

**OIL**
- Vitamin A, E

**MILK**
- Vit A, D
- Ca

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

**SALT**
- Iodine

**SUGAR**
- Vitamin A
FORTIFICATION: MAIN ADVANTAGES

- Preventive population-wide approach
- Consistent delivery
- Safe in low daily doses
- Minimal behaviour change
- Low cost
- Multiple micronutrient delivery
- Enhances other health strategies
HOW IS MAIZE MEAL FORTIFIED?

– Maize/corn
HOW IS MAIZE MEAL FORTIFIED?

- Flour fortification: large scale operations
FORTIFICATION PROGRAMMES:

- 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!
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
### WHICH FE SOURCE TO CHOOSE?

WHO guidelines on maize fortification (2016)

<table>
<thead>
<tr>
<th>Nutrient&lt;sup&gt;b&lt;/sup&gt;</th>
<th>Flour-extraction rate&lt;sup&gt;c&lt;/sup&gt;</th>
<th>Compound</th>
<th>Nutrient concentration to be added by estimated availability/consumption (mg nutrient/kg maize flour)&lt;sup&gt;d&lt;/sup&gt;</th>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>75 g/day&lt;sup&gt;a&lt;/sup&gt;</td>
<td>75–149 g/day</td>
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<tr>
<td>Iron&lt;sup&gt;f&lt;/sup&gt;</td>
<td>Low</td>
<td>NaFe-EDTA</td>
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<tr>
<td></td>
<td>Low</td>
<td>Ferrous sulfate</td>
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<td></td>
<td>Low</td>
<td>Ferrous fumarate</td>
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<tr>
<td></td>
<td>Low</td>
<td>Electrolytic iron</td>
<td>NR</td>
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<td>NaFe-EDTA</td>
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<td>High</td>
<td>Electrolytic iron</td>
<td>NR</td>
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<tr>
<td>Folic acid</td>
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<tr>
<td>Vitamin A</td>
<td>Low or high</td>
<td>Vitamin A palmitate</td>
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<tr>
<td>Zinc</td>
<td>Low</td>
<td>Zinc sulfate/zinc oxide&lt;sup&gt;3&lt;/sup&gt;</td>
<td>95</td>
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<tr>
<td></td>
<td>High</td>
<td>Zinc sulfate/zinc oxide</td>
<td>100</td>
</tr>
<tr>
<td>Vitamin B&lt;sub&gt;12&lt;/sub&gt;&lt;sup&gt;h&lt;/sup&gt;</td>
<td>Low or high</td>
<td>Cyanocobalamin</td>
<td>0.04</td>
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</tbody>
</table>

Relative Bioavailability:

- >100
- 100
- 75
RESEARCH SETUP 1

**SUPER**
- Blank
- Fe sulfate
- Fe fumarate
- Fe EDTA (ferrazine)
- Fe EDTA (chinese)
- Fe electrolyt.
- Zn oxide
- Zn gluconate

120% dosage →
- 20 ppm
- 20 ppm
- 15 ppm
- 15 ppm
- 35 ppm
- 30 ppm
- 30 ppm

**Storage conditions:**
- 25°C
- 35% RH
RESEARCH SETUP 1

- Porridge evaluation
  - Cooking trials

- Pasting experiments: rheometer

\[ \Delta E^* = \sqrt{\Delta L^2 + \Delta a^2 + \Delta b^2} \]
PASTING PROFILE

SUPER

WEEK 10

DAY 1

[Graphs showing viscosity and temperature over time for different compounds, including Blank, Iron sulphate, Iron fumarate, Iron EDTA ferrazole, Iron EDTA Chinese, Electrolytic Iron, Zinc oxide, Zinc gluconate, and Temperature.]

- Viscosity (cP)
- Temperature (°C)
- Time (min)
CONCLUSIONS RESEARCH SETUP 1

- No systematic differences in porridge colour or pasting behaviour due to
  - Iron or zinc source
  - Storage time

However:
- porridge was made with demi-water => reality = tap water!
- No full premix was used
RESEARCH SETUP 2

SPECIAL MAIZE MEAL

- Blank
- Fe fumarate (ferrazone)
- Fe EDTA (Chinese)
- Fe electrolyt.

- 1 week storage
- 25°C
- 35% RH

Demi-water
Tap water

- Cooking trials
- Pasting experiments
ΔE

Tap water

Demineralized water

Blank

Iron EDTA ferrazone

Iron EDTA Chinese

Iron fumarate

Electrolytic iron
Significantly different from other Fe sources

ΔE = 2 -> visible colour difference in porridge
-> in contrast with Haybech et al. (2016): visible colour change only from ΔE > 3
PASTING

Graph showing the viscosity and temperature over time for different water samples. The graph includes lines for Blank (demineralized), Iron fumarate 20 ppm (demineralized), Blank (tap), Iron fumarate 20 ppm (tap), Iron EDTA 15 ppm (demineralized), Electrolytic iron 35 ppm (demineralized), Iron EDTA 15 ppm (tap), and Electrolytic iron 35 ppm (tap).

Key points:
- Demi-water
- Tap water

Viscosity (CP) on the y-axis and Time (min) on the x-axis.
RESEARCH SETUP 3

SPECIAL MAIZE MEAL

- 1 week storage
- 25°C
- 35% RH

Diagram:
- Blank
- Fe EDTA (ferrazone)
- Fe EDTA (ferrazone)
- Fe EDTA (ferrazone)

- 15 ppm
- 30 ppm
- 45 ppm

- Demi-water
- Tap water

- Cooking trials
Significantly different $\Delta E = 2$ $\rightarrow$ visible colour difference in porridge

$\rightarrow$ in contrast with Haybech (2016): visible colour change only from $\Delta E > 3$
CONCLUSIONS RESEARCH SETUP 2&3

- Differences in porridge colour or pasting behaviour due to
  - Water composition (demi or tap)
  - Interaction Fe-source and tap water
    - Fe fumarate (20 ppm Fe)
    - NaFeEDTA (45 ppm Fe)
SPECIAL MAIZE MEAL

**Storage conditions:**
- **25°C**
  - Blank
  - Premix without Fe (DSM)
  - Premix without Fe (Mühlen.)
  - Premix Fe EDTA (Mühlen.)
  - Premix Fe fumarate (DSM)
  - Premix Fe electrolyt. (DSM)

- **35°C**
  - Blank
  - Premix without Fe (DSM)
  - Premix without Fe (Mühlen.)
  - Premix Fe EDTA (Mühlen.)
  - Premix Fe fumarate (DSM)
  - Premix Fe electrolyt. (DSM)

100% dosage → 160 ppm 300 ppm 300 ppm 300 ppm 220 ppm 180 ppm

**Cooking trials**
- Stainless steel
- Aluminum
<table>
<thead>
<tr>
<th></th>
<th>Stainless steel (25°C)</th>
<th>Aluminium (25°C)</th>
<th>Stainless steel (35°C)</th>
<th>Aluminium (35°C)</th>
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<tbody>
<tr>
<td>Blank</td>
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<td>Premix without iron (DSM)</td>
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<td>Premix without iron (Mühlenchemie)</td>
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<td>Premix iron fumarate (DSM)</td>
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</tbody>
</table>

**WEEK 5**

**WEEK 10**
Aluminum causes more yellow colour.

\[ \Delta E = 2 \]
TAKE HOME MESSAGES

- Visible colour change in ‘pap’: $\Delta E \sim 2$
- Porridge colour influenced by many factors:
  ⇒ Storage conditions of maize meal, maize composition, premix composition, water composition and type of cooking pot
- Interaction between Fe-source and minerals in tap water was observed
- NaFeEDTA can be applied without major discoloration below 40 ppm of Fe
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