FACULTY OF
BIOSCIENCE ENGINEERING

DEPARTMENT OF APPLIED BIOSCIENCES (BW15)

LABORATORY OF CEREAL TECHNOLOGY

END PRODUCT QUALITY: BAKING TRIALS ON WHEAT FLOUR AND MAIZE MEAL PORRIDGE

Filip Van Bockstaele, 16-05-2017, QAQC training on flour fortification, Lusaka, Zambia

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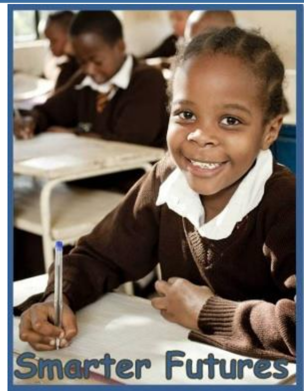

FORTIFICATION: CHALLENGES

gouvernement

Legislation
Technical standards
Inspection/control
Information

industry

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

distribution

consumer

Are products accepted?
Are products bought?
Are products consumed?

Micronutrient status?
=> Continuous **monitoring** system needed!

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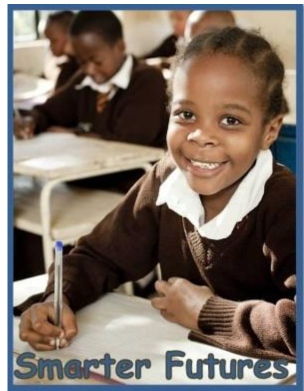
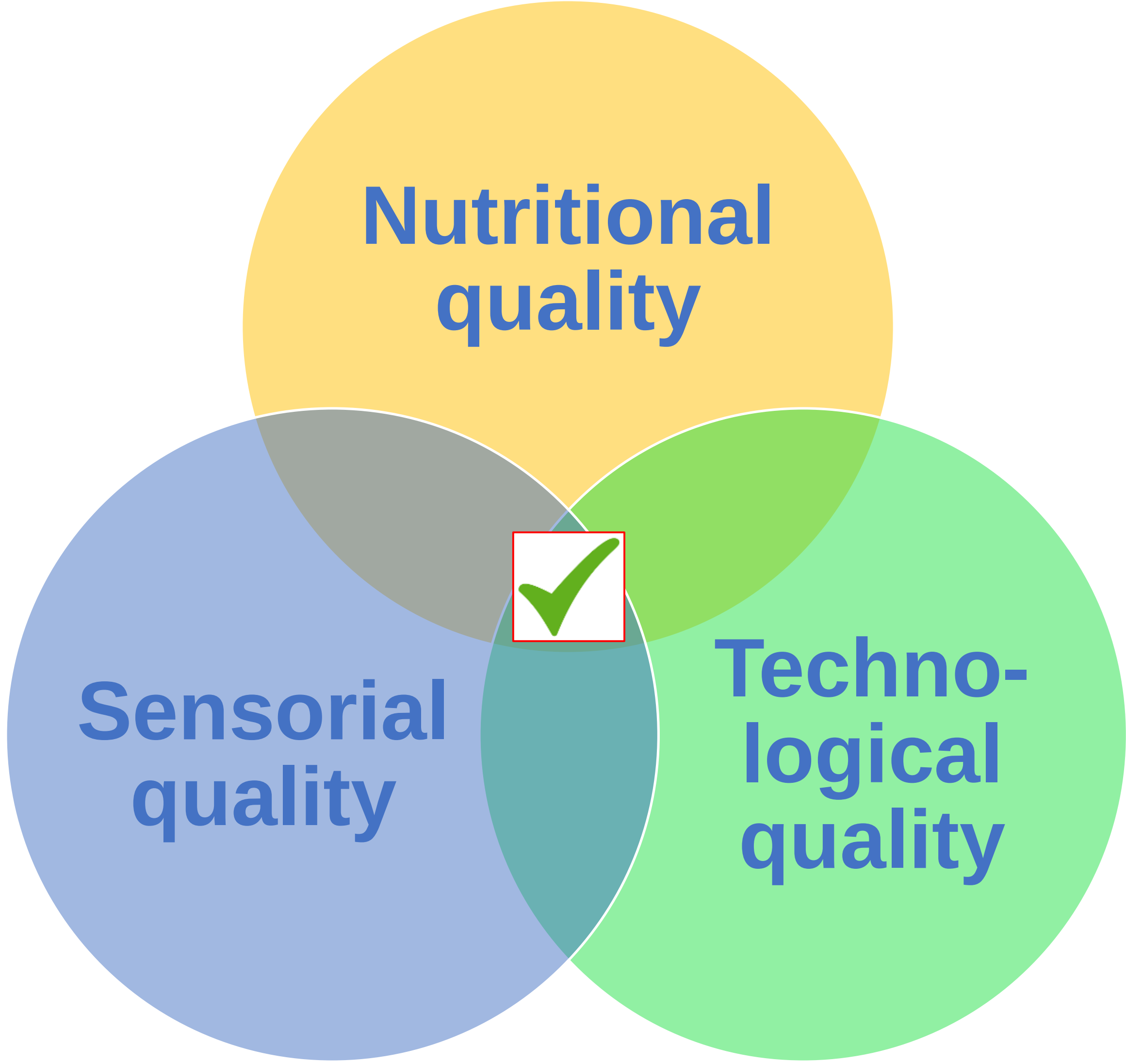


FORTIFICATION: PREREQUISITE

- Fortification is desired to not
  - Impact the production process of the food
  - Change the sensory properties of the produced fortified foods



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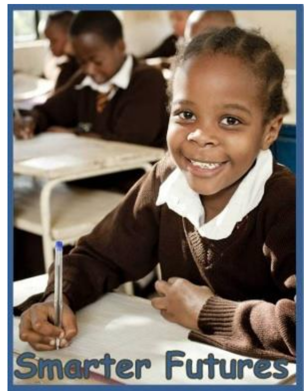
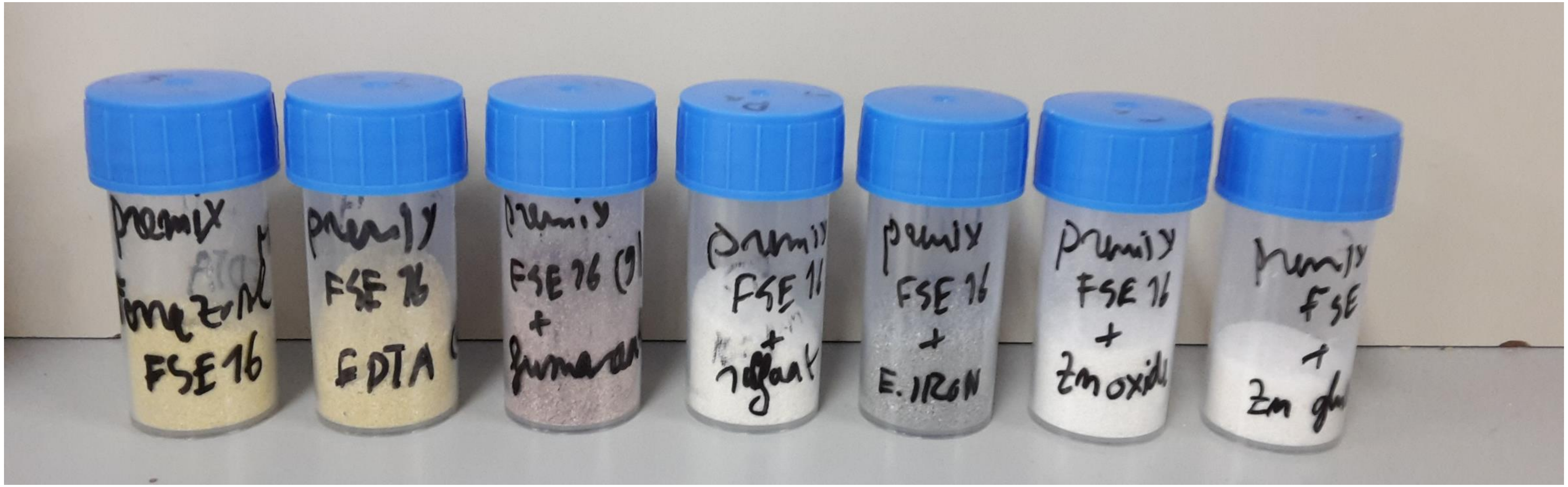


FORTIFICATION PREMIX

– Low quantities (eg 300 ppm -> 0,3 g per kg)
– particle size, different types of components at different concentrations, colour



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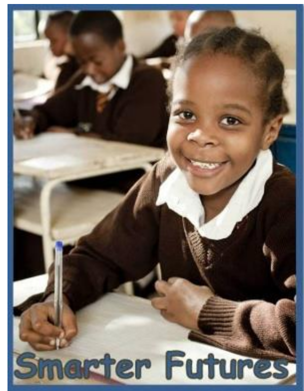
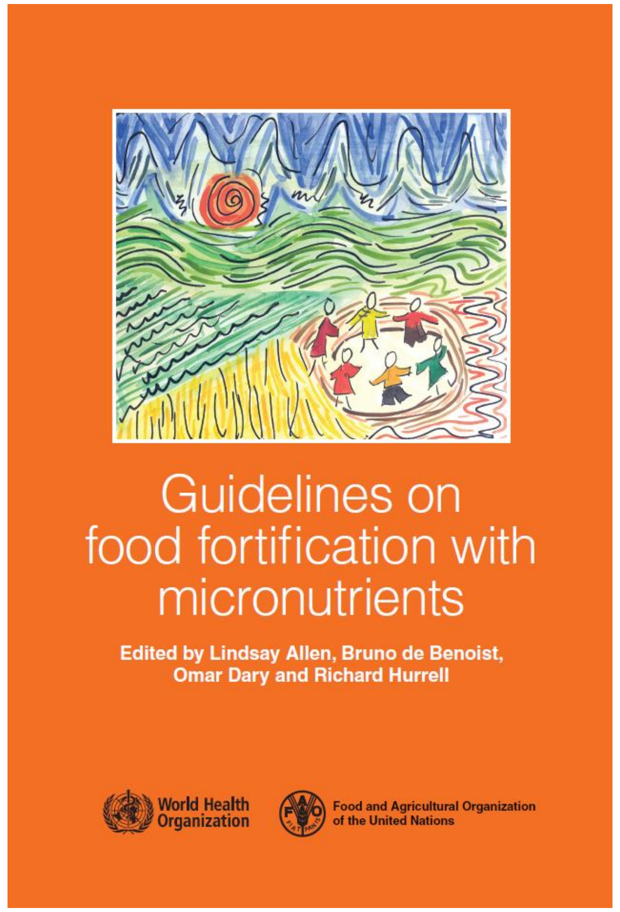


PROBLEM STATEMENT



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

Nutrient	Technological/sensory	Safety	Cost
Vitamin A	X	XXX	XXX[a]
Vitamin D	–	X	X
Vitamin E	–	X	XXX
Vitamin C	XX	X	XXX[b]
Thiamine (vitamin B_1)	–	–	–
Riboflavin (vitamin B_2)	XX	–	–
Niacin (vitamin B_3)	–	XXX[c]	X
Vitamin B_6	–	X	–
Folic acid	–	XXX[d]	–
Vitamin B_{12}	–	–	X
Iron[e]	XXX	XX	X
Zinc	XX	XXX	X
Calcium	X	XX	XXX[f]
Selenium	–	X	X
Iodine	X	XXX	–

–, no constraint; X, a minor constraint; XX, moderate constraint; XXX, major constraint.

[a] If an oil-based form is used to fortify oils or fats, costs can be reduced.

[b] Cost constraints are mainly a consequence of losses during manufacturing, storage, distribution and cooking which mean that a considerable overage is required.

[c] Much less of a concern if niacinamide, as opposed to nicotinic acid, is used as the fortificant.

[d] The risk of adverse effects is minimized by the co-addition of vitamin B_{12}.

[e] Refers to the more bioavailable forms.

[f] Cost constraints are mainly a consequence of the need to add such large amounts.

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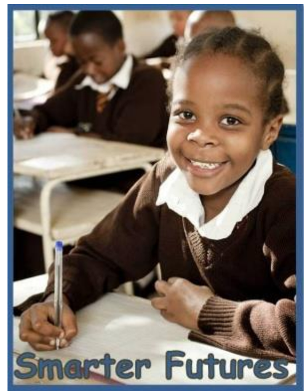

FE-SOURCES

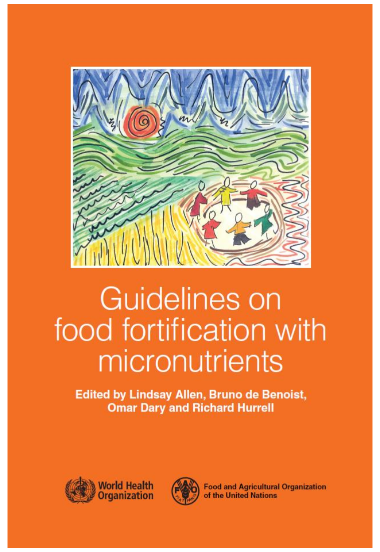

TABLE 5.1

Key characteristics of iron compounds commonly used for food fortification purpose: solubility, bioavailability and cost

Compound	Iron content (%)	Relative bioavailability[a]	Relative cost[b] (per mg iron)
Water soluble			
Ferrous sulfate. $7H_20$	20	100	1.0
Ferrous sulfate, dried	33	100	1.0
Ferrous gluconate	12	89	6.7
Ferrous lactate	19	67	7.5
Ferrous bisglycinate	20	>100[c]	17.6
Ferric ammonium citrate	17	51	4.4
Sodium iron EDTA	13	>100[c]	16.7
Poorly water soluble, soluble in dilute acid			
Ferrous fumarate	33	100	2.2
Ferrous succinate	33	92	9.7
Ferric saccharate	10	74	8.1
Water insoluble, poorly soluble in dilute acid			
Ferric orthophosphate	29	25–32	4.0
Ferric pyrophosphate	25	21–74	4.7
Elemental iron	–	–	–
H-reduced	96	13–148[d]	0.5
Atomized	96	(24)	0.4
CO-reduced	97	(12–32)	<1.0
Electrolytic	97	75	0.8
Carbonyl	99	5–20	2.2
Encapsulated forms			
Ferrous sulfate	16	100	10.8
Ferrous fumarate	16	100	17.4

Best option for cereal flours with high turnover, typically use within 1 month for humid, warm climate and 3 months in dry, cold climate

High bio-availibility, especially in high phytate flours

Ferrous sulphate can cause rancidity depending on fat content, climate and type of flour

More stable, physical separation from food components and thus slow down sensory changes

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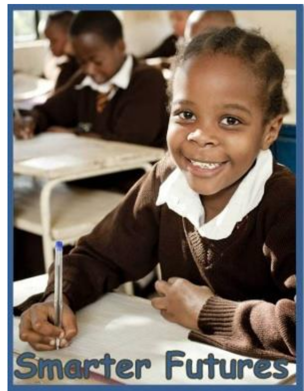
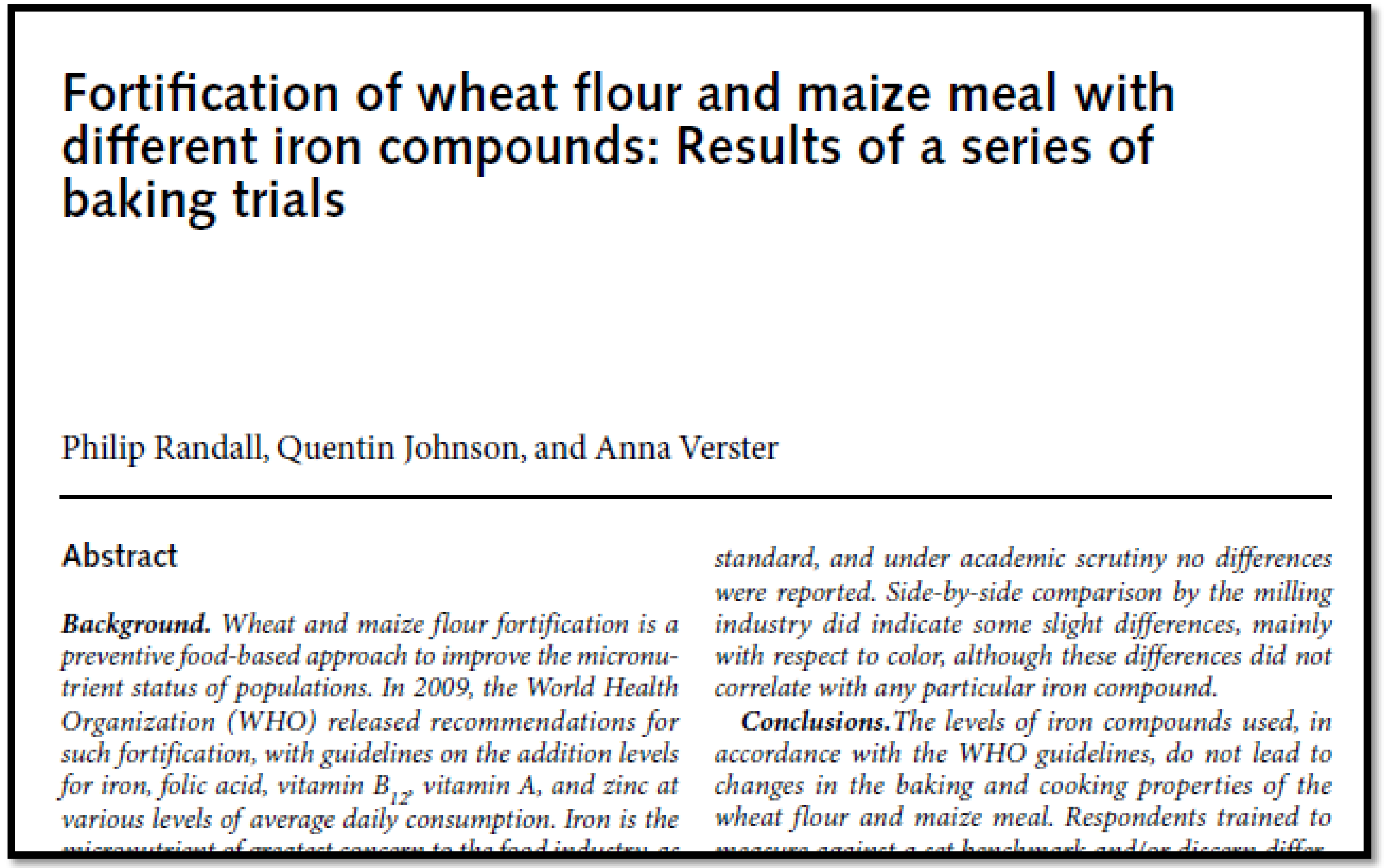


Food and Nutrition Bulletin, vol. 33, n°4 (2012)



Fortification of wheat flour and maize meal with different iron compounds: Results of a series of baking trials

Philip Randall, Quentin Johnson, and Anna Verster

Abstract

Background. Wheat and maize flour fortification is a preventive food-based approach to improve the micronutrient status of populations. In 2009, the World Health Organization (WHO) released recommendations for such fortification, with guidelines on the addition levels for iron, folic acid, vitamin B_{12}, vitamin A, and zinc at various levels of average daily consumption. Iron is the

standard, and under academic scrutiny no differences were reported. Side-by-side comparison by the milling industry did indicate some slight differences, mainly with respect to color, although these differences did not correlate with any particular iron compound.

Conclusions. The levels of iron compounds used, in accordance with the WHO guidelines, do not lead to changes in the baking and cooking properties of the wheat flour and maize meal. Respondents trained to

Impact of Fe and Zn fortification on the properties of maize meal porridge (2017)

Under publication…

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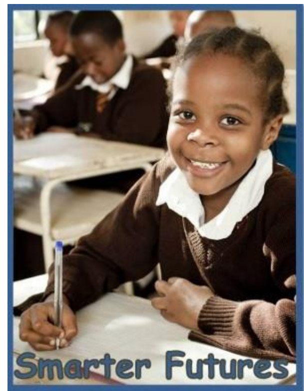

WHEAT FLOUR / BREAD

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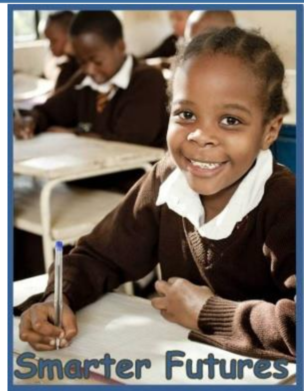


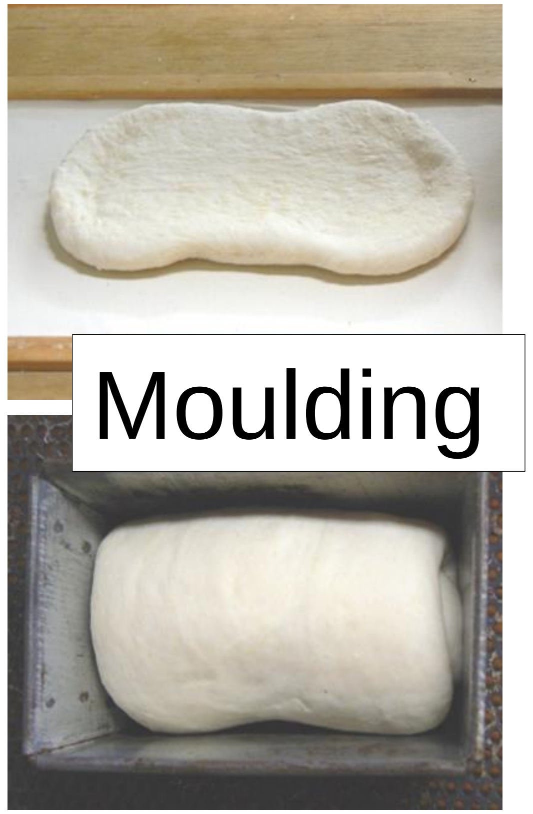
BREADMAKING

Mixing

wheat flour, water, yeast, salt
bread improvers, other flours

→ Dough rest →

→ 1^{st} fermentation ↓



Moulding

← 2^{nd} fermentation

←

Baking

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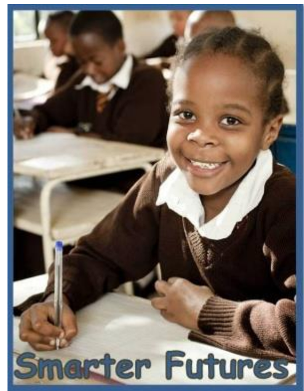
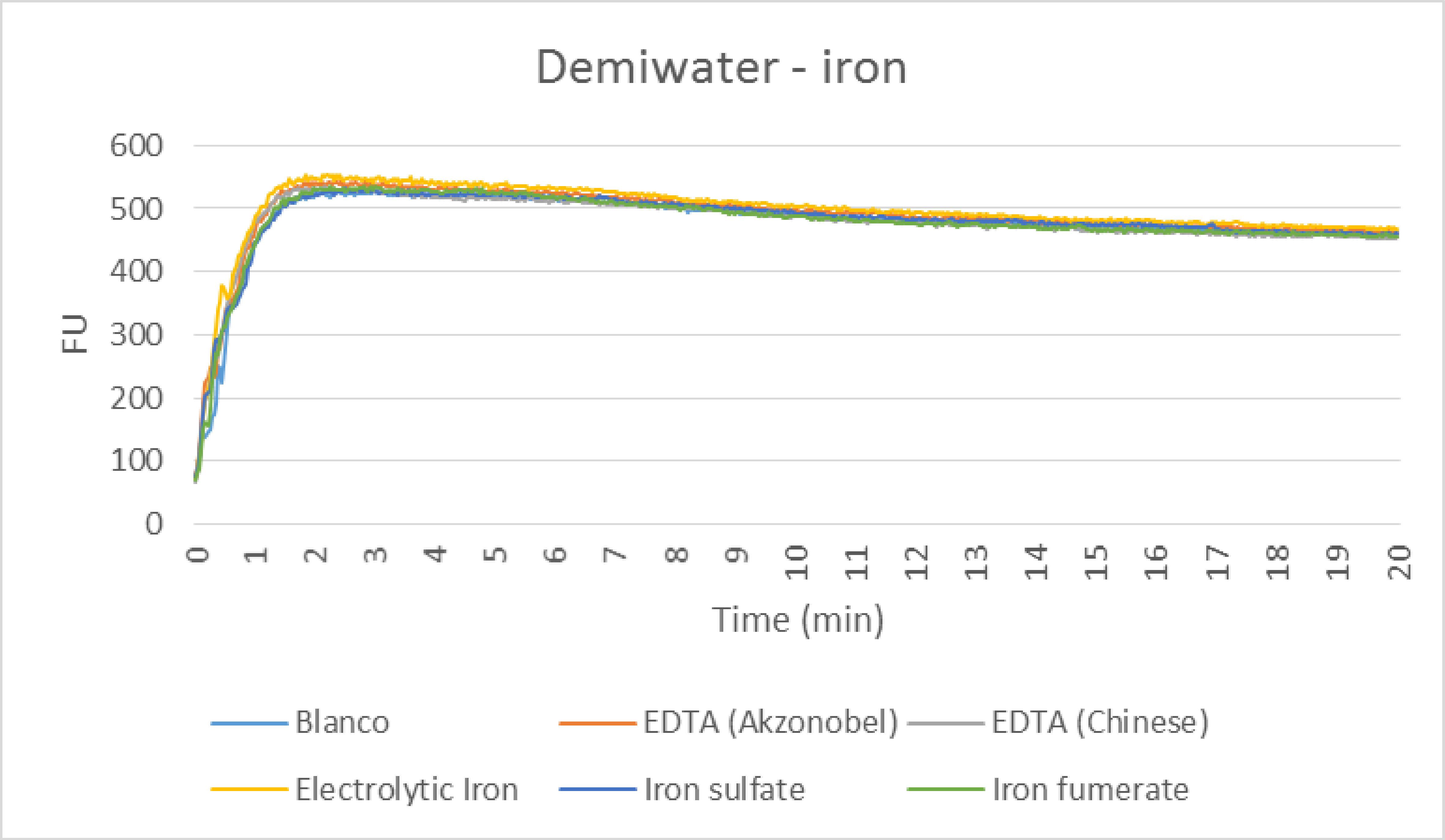


IMPACT ON MIXING BEHAVIOUR

– Farinograph mixing profile



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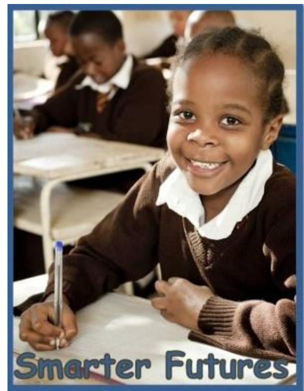
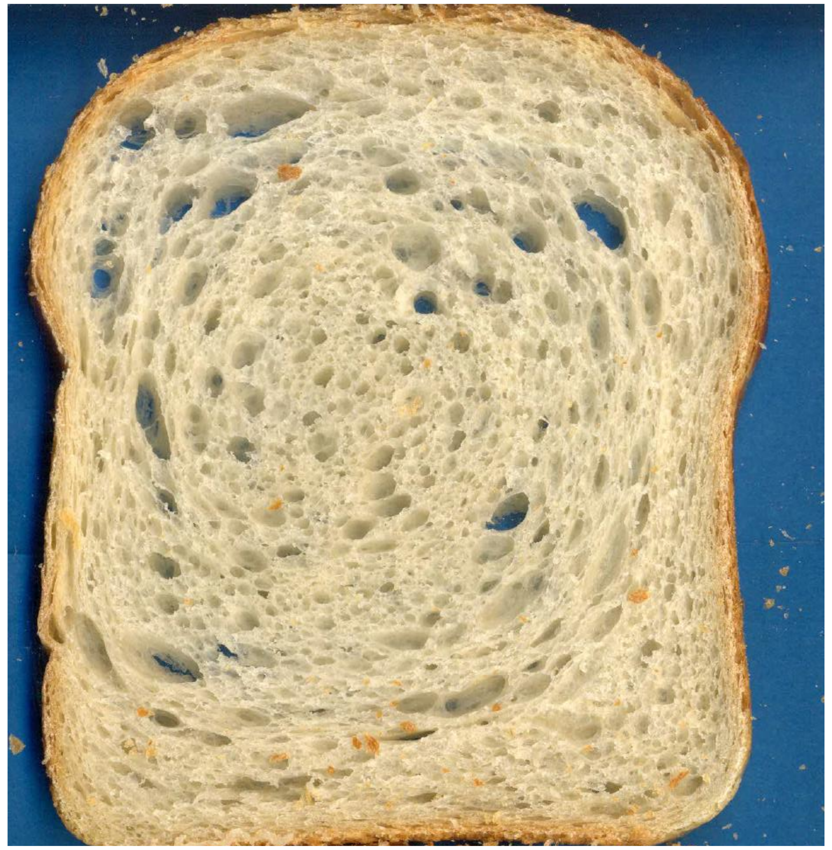
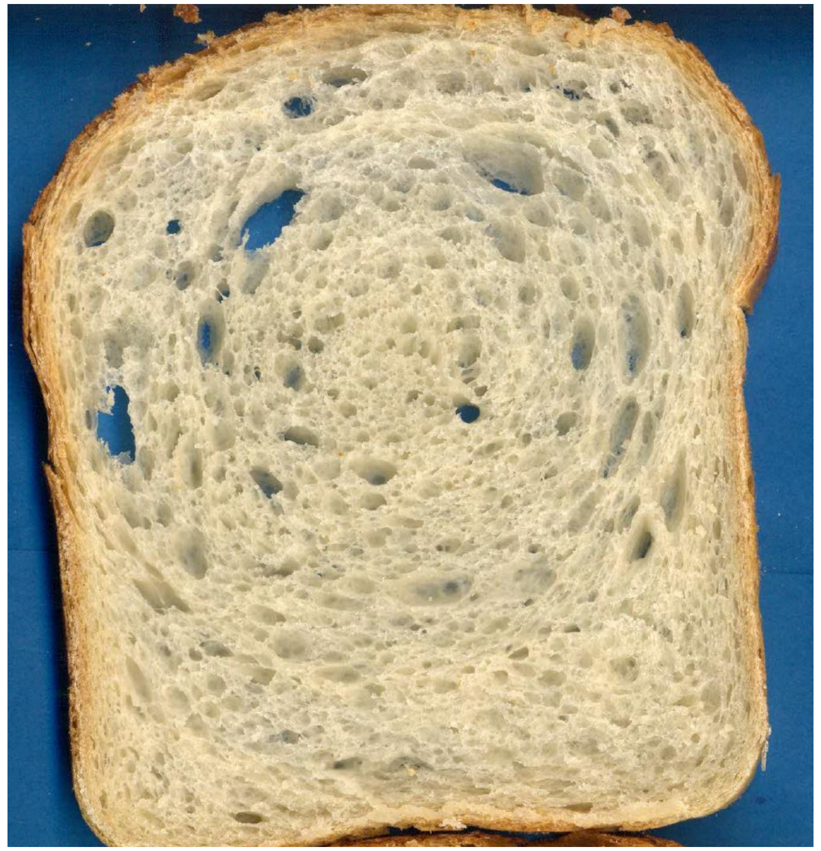


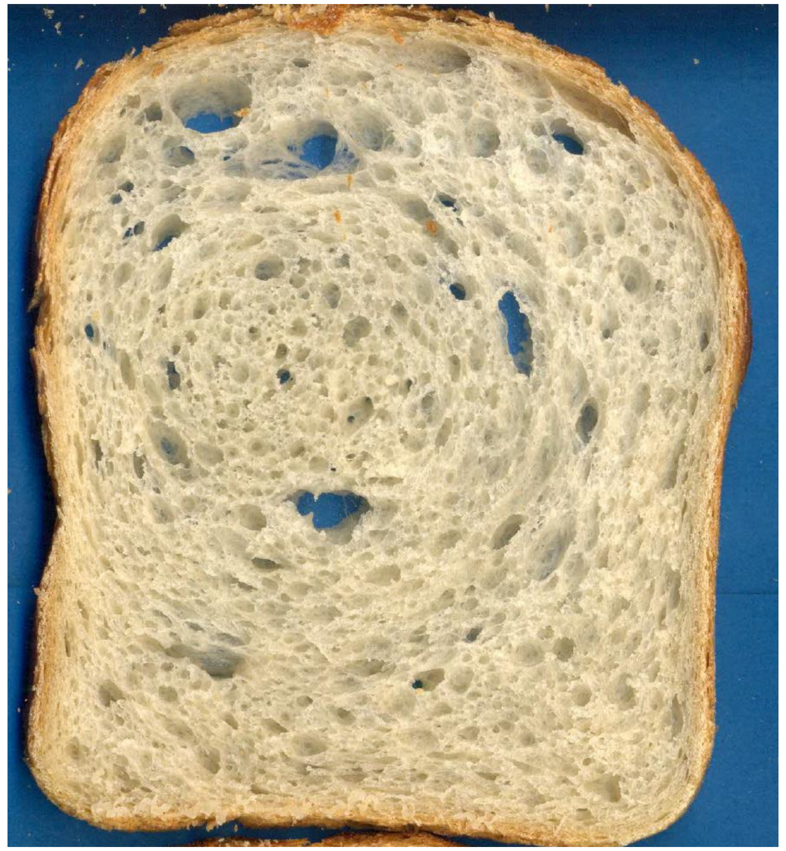
BREADS WITH NAFE-EDTA



30 ppm



60 ppm



90 ppm

No difference in volume, texture or crumb colour

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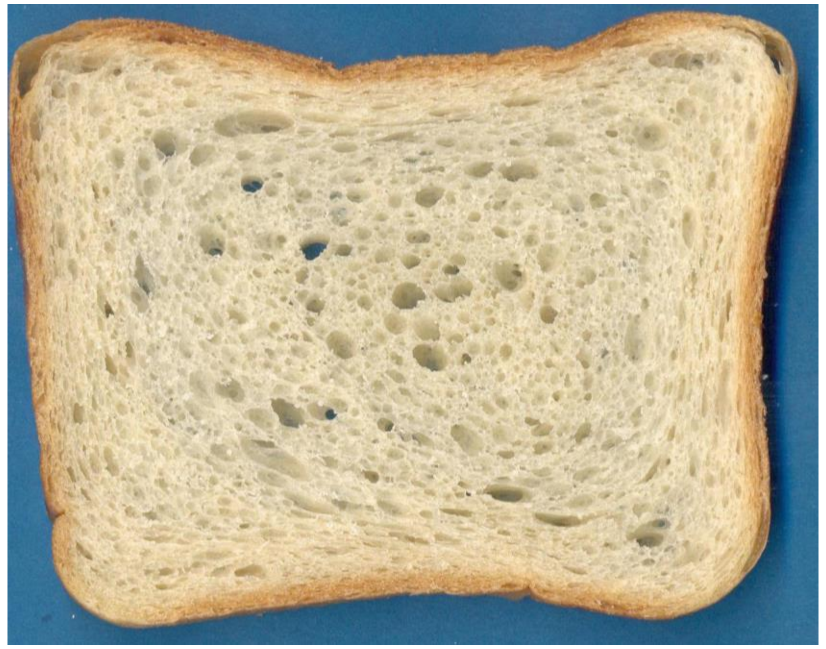
FORTIFIED BREADS FULL PREMIX



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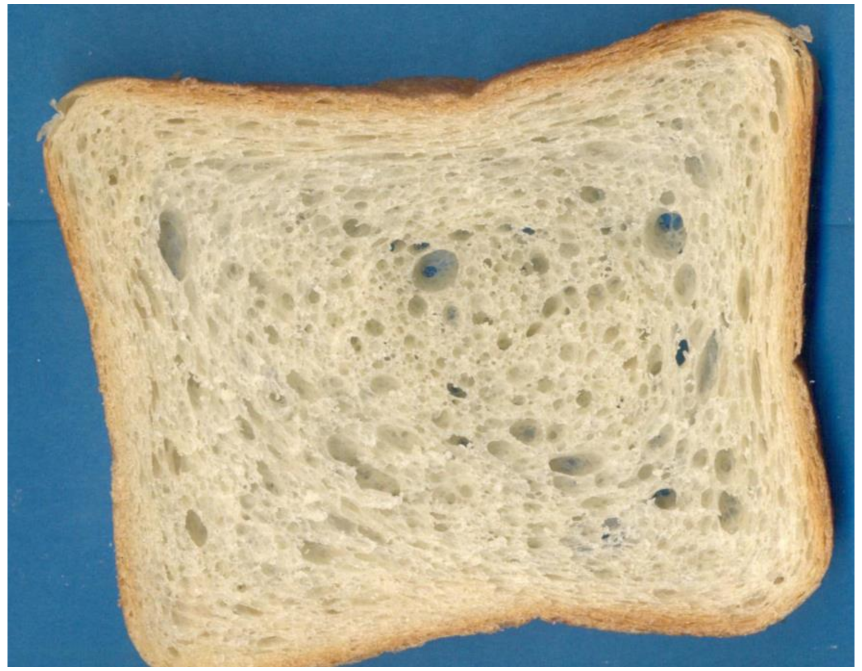
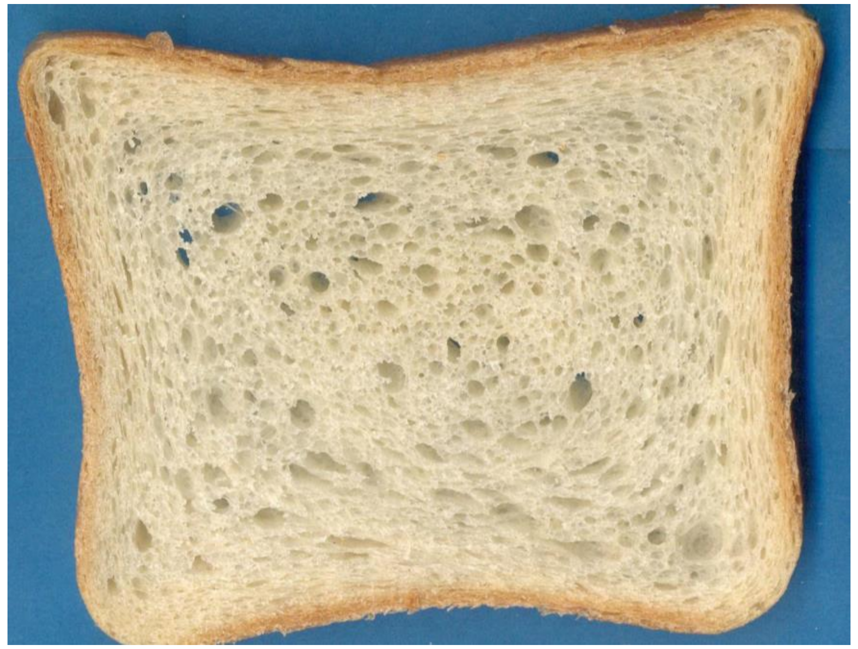


East-African standard

fumarate



South-African standard

EDTA

No differences in texture and crumb colour

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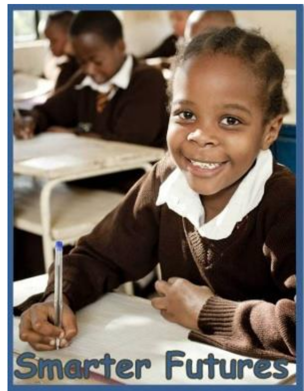


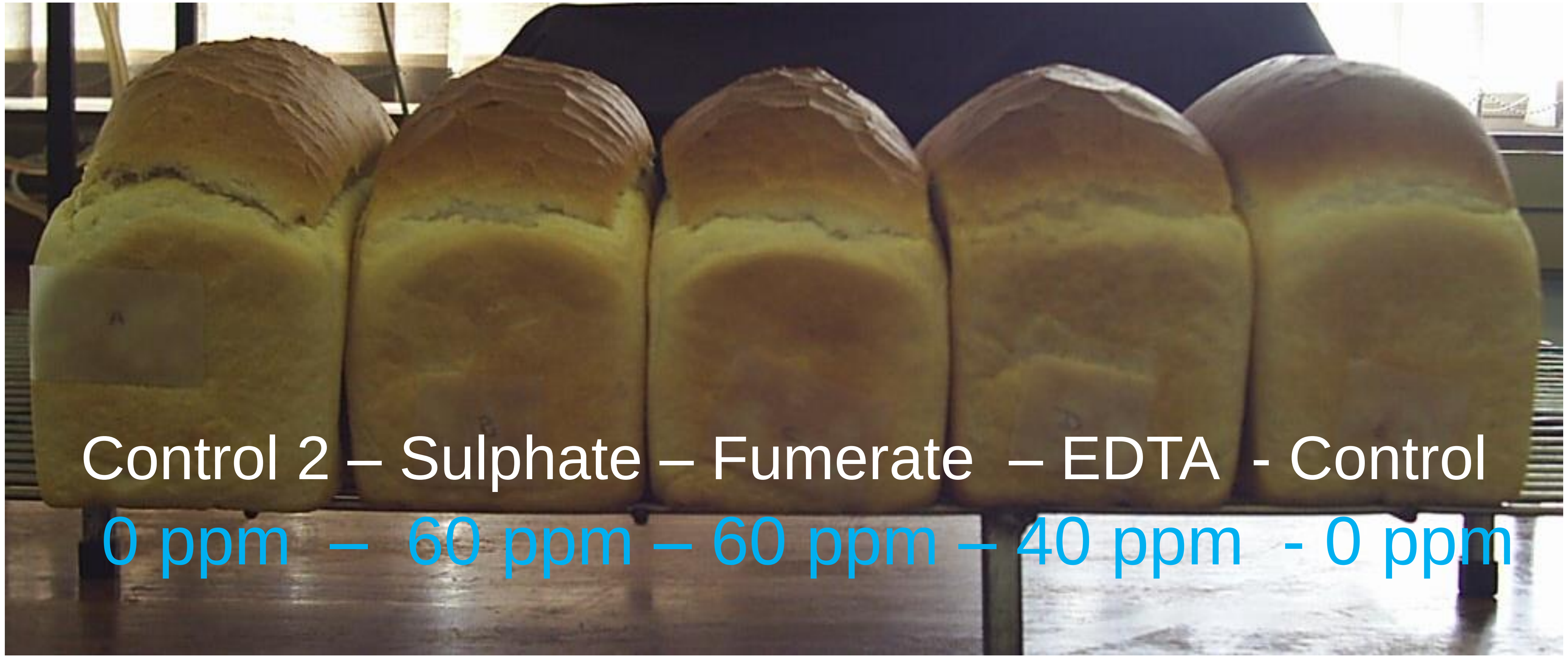
Source:
Philip Randall

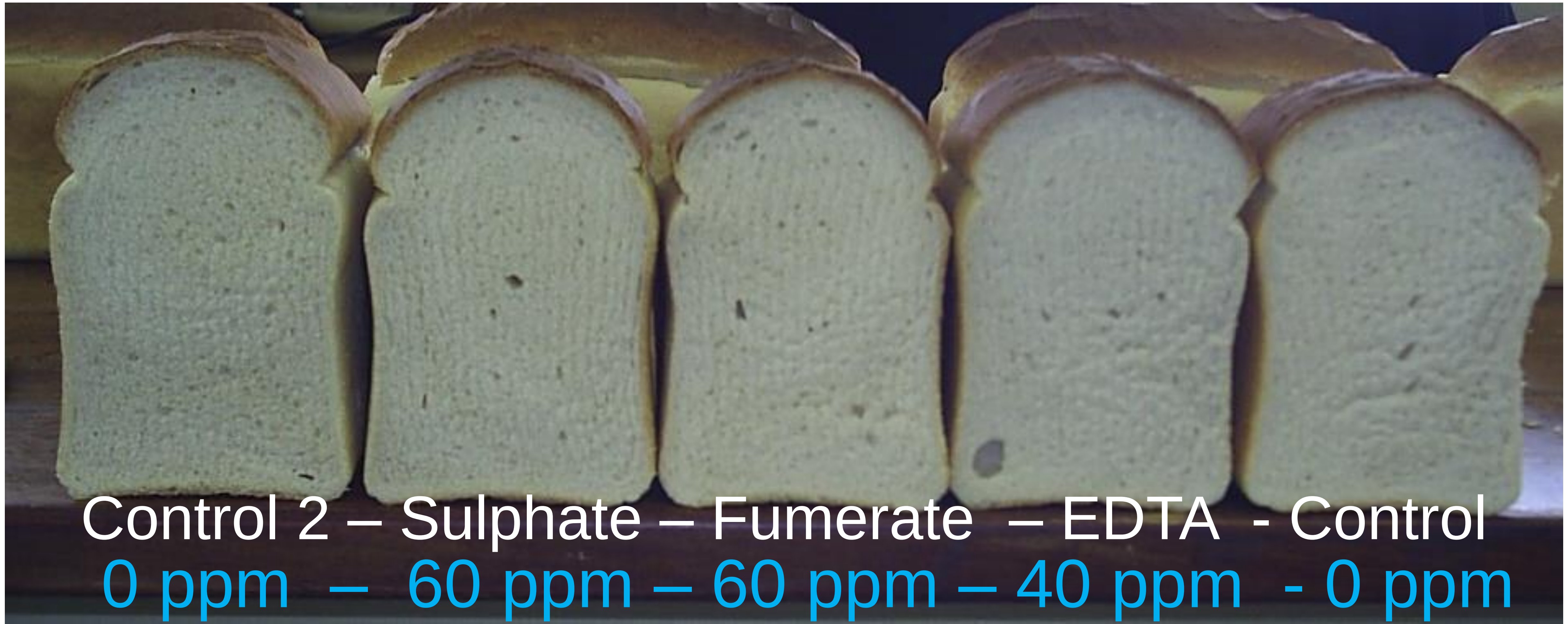
SAGL

Premix

@75-149 g/day consumption

WHO guidelines





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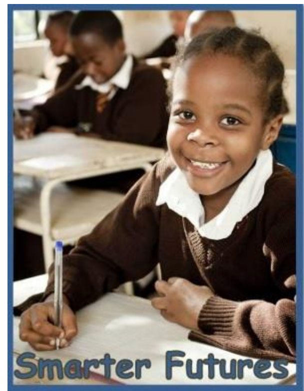

BREAD SCORE (BAKHRESA MILLS, TANZANIA)

TABLE 5. Bakhresa Mills, Tanzania: Results for bread[a]

Characteristic	Perfect score	Control 1	Ferrous fumarate	Ferrous sulfate	NaFeEDTA
Original sample					
Bread volume	30	27	27	28	28
Appearance	20	18	18	18	18
Texture	25	24	24	24	24
Crumb color	14	14	14	14	14
Crumb grain	7	5	5	5	5
Oven spring	4	3	3	2	3
Total	100	91	91	91	92
Retention samples					
Bread volume	30	27	27	27	23
Appearance	20	18	16	12	17
Texture	25	24	24	24	23
Crumb color	14	13	12	12	12
Crumb grain	7	6	5	5	5
Oven spring	4	3	3	3	2
Total	100	91	87	83	82

NaFeEDTA, sodium iron ethylenediaminetetraacetate
a. Minimum acceptable score > 75.

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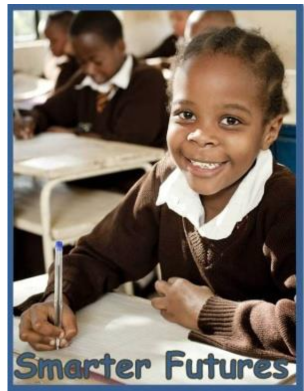

BREAD ACCEPTABILITY

TABLE 7. Kenyatta University, Kenya: Acceptability of bread[a]

Question	Control	Ferrous fumarate	Ferrous sulfate	NaFeEDTA
Original samples				
Is this product generally ACCEPTABLE ?	1.1 (0.3)	1.1 (0.3)	1.1 (0.3)	1.1 (0.3)
Would you BUY this product if it was commercially available ?	1.1 (0.3)	1.1 (0.3)	1.1 (0.3)	1.1 (0.4)
Would you BUY the product knowing it contained health benefits?	1.1 (0.3)	1.1 (0.3)	1.1 (0.3)	1.0 (0.0)
Retention samples				
Is this product generally ACCEPTABLE?	1.1 (0.3)	1.2 (0.4)	1.2 (0.4)	1.3 (0.5)
Would you BUY this product if it was commercially available?	1.1 (0.2)	1.2 (0.4)	1.3 (0.5)	1.4 (0.5)
Would you BUY this product knowing it contained health benefits?	1.0 (0.0)	1.1 (0.3)	1.1 (0.3)	1.1 (0.2)

NaFeEDTA, sodium iron ethylenediaminetetraacetate. Questions were in English.

a. Numbers in parentheses are 1 SD for n = 20 (original samples) and n = 19 (retention samples).

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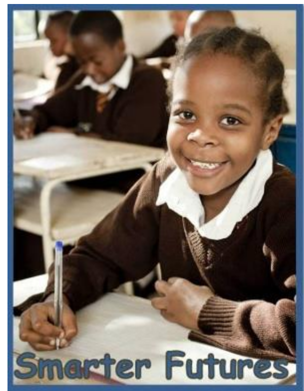

WHEAT FLOUR / CHAPPATI

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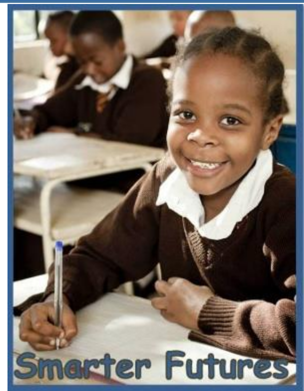

TANZANIAN WHEAT FLOUR - MILL

EDTA - Control

Sulphate - Control

Fumerate - Control

Slight differences in colour but not related to a particular iron source

Chapatti quality = normal

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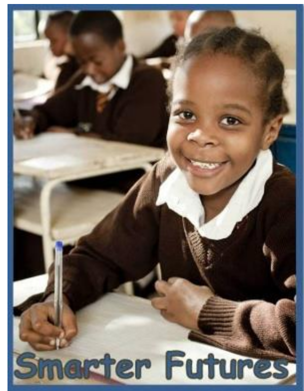

MAIZE MEAL / PORRIDGE

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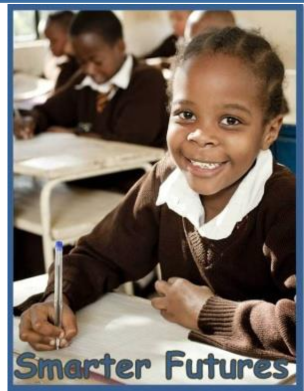

PORRIDGE PRODUCTION

Ingredients → Processing → End product

Water/maize ratio

Stirring

Cooking time

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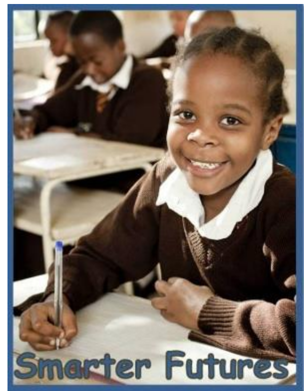

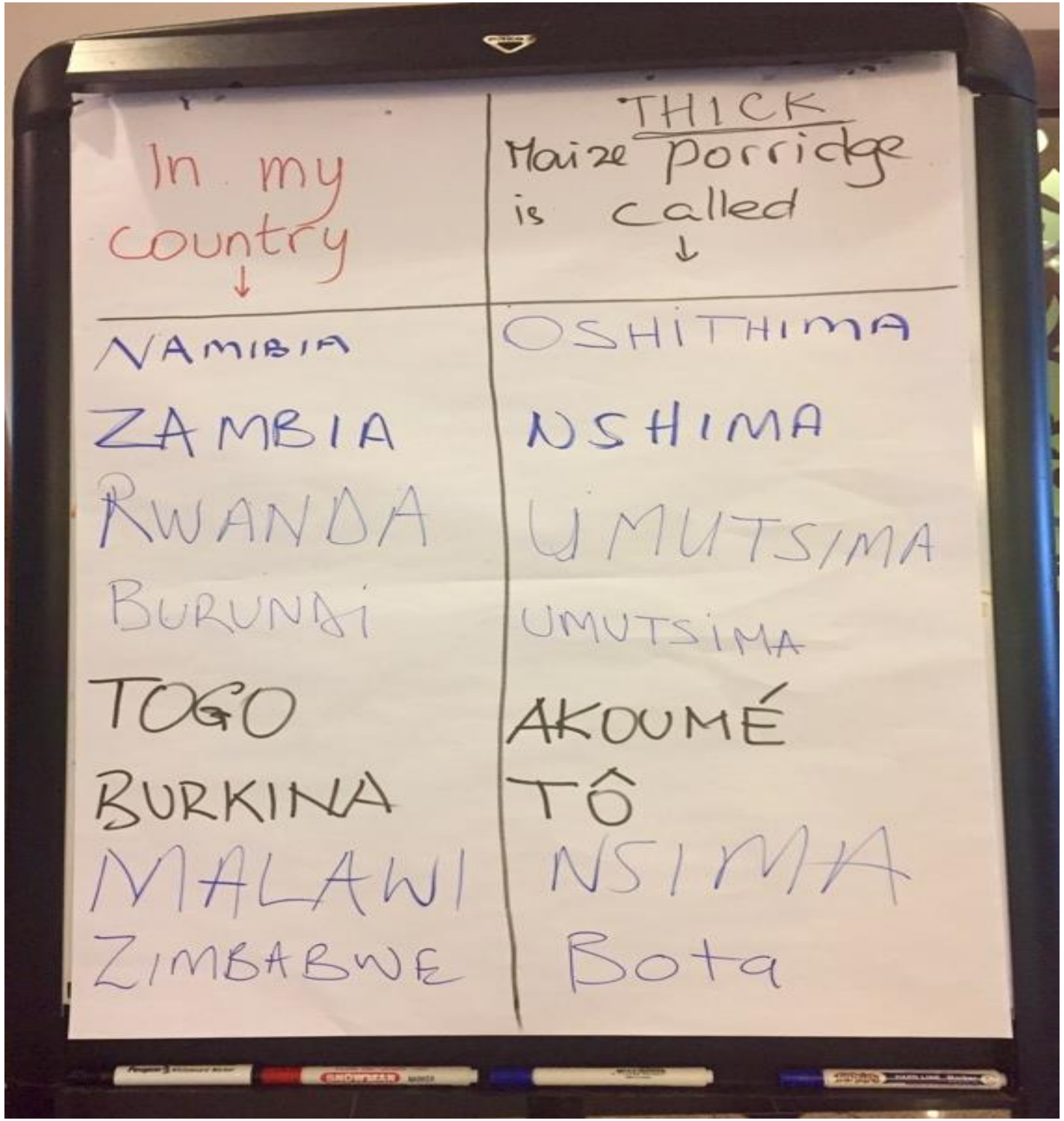
In my country
THICK Maize porridge is called
NAMIBIA
OSHITHIMA
ZAMBIA
NSHIMA
RWANDA
UMUTSIMA
BURUNDI
UMUTSIMA
TOGO
AKOUMÉ
BURKINA
TÔ
MALAWI
NSIMA
ZIMBABWE
Bota


In my Country
Thick maize porridge is called
MALAWI
NSIMA
ZIMBABWE
1) SADZA
2) ISTHWALA
TANZANIA
UGALI
South Africa
① PAP
② Putu
③ Liphalishi
Kenya
ugali/Sima

PART1: IMPACT OF IRON AND ZINC FORTIFICATION ON PORRIDGE COLOUR

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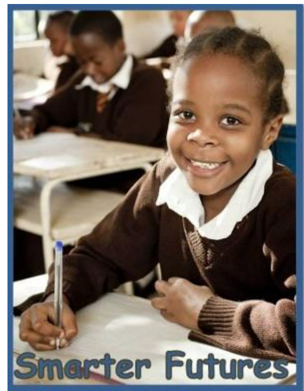
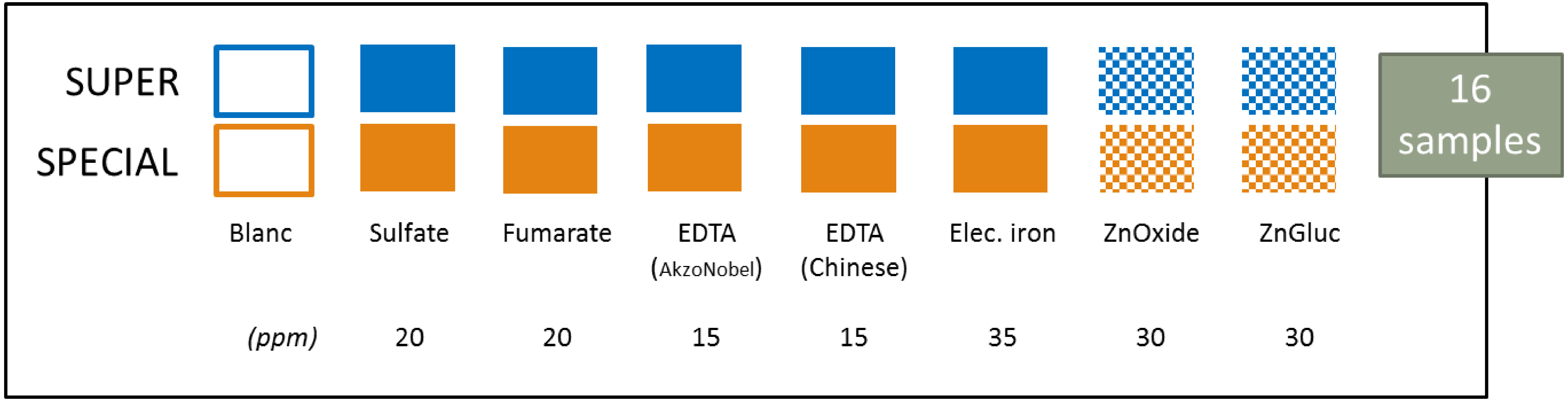
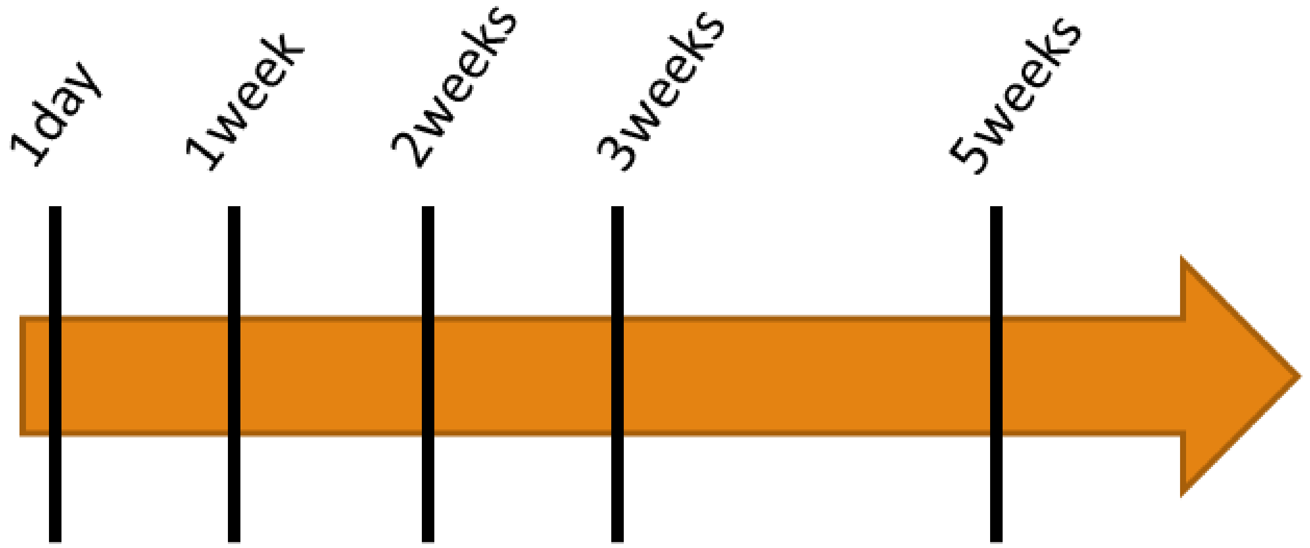


PART 1: SAMPLES





- 120% overage
- Samples stored at 25°C

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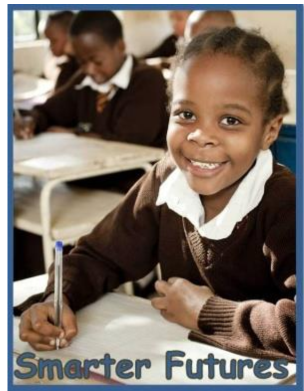
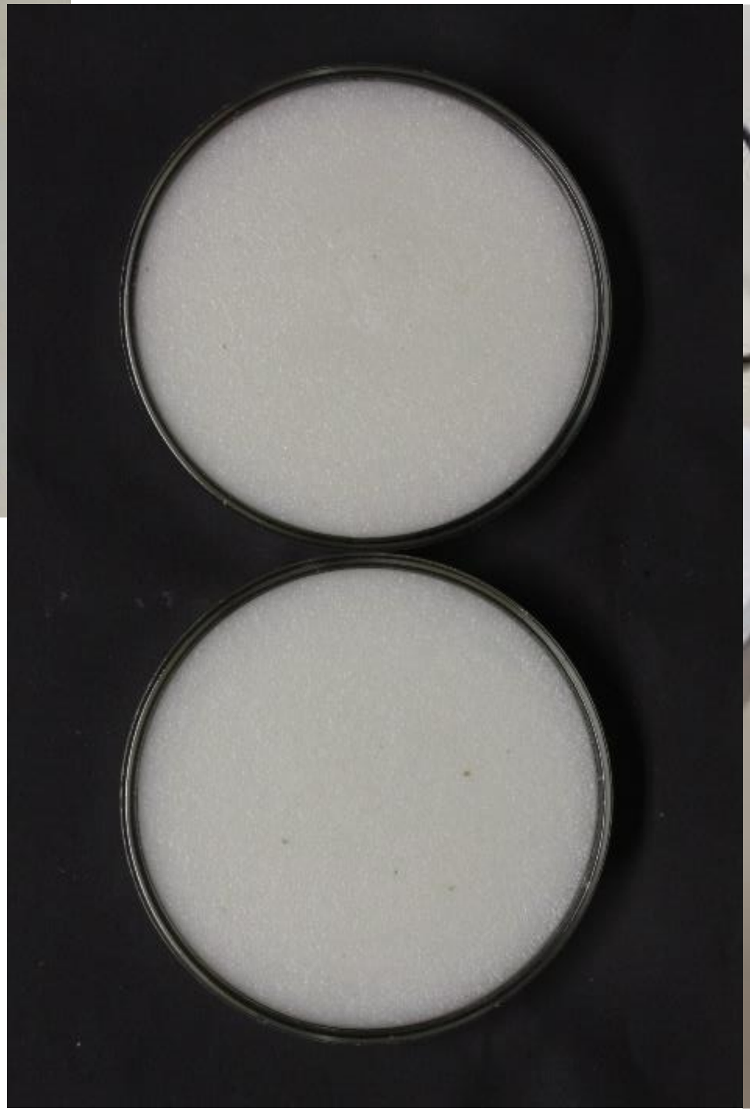


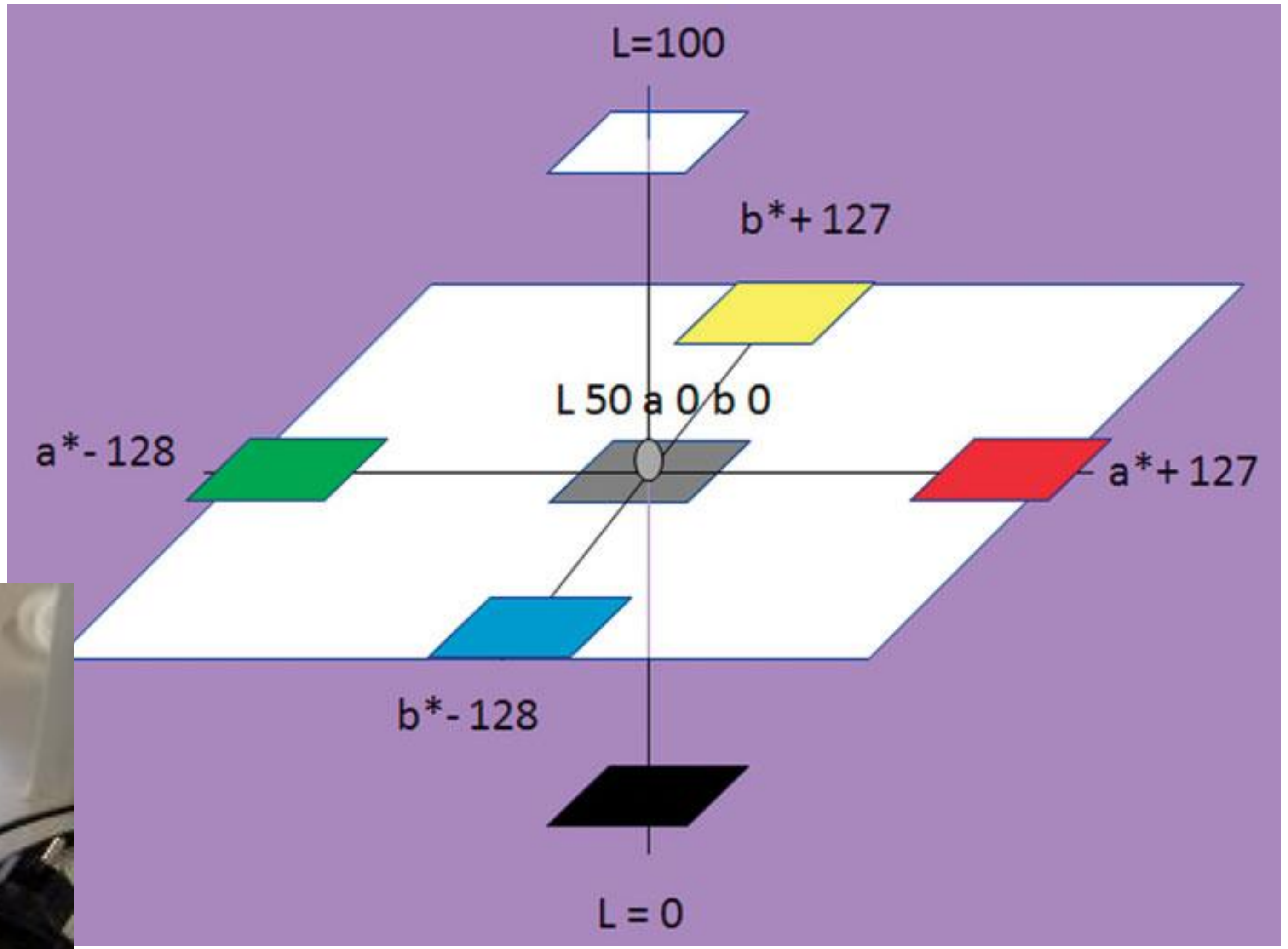
PART 1: TEST PROCEDURE

Evaluation of maize flour

- cooking trial (duplicate)
  - Photo
  - Colorimeter (2*3 cups)

(D65/10°/SCE-mode)





$$\Delta Eab* = \left(\Delta L^2 + \Delta a^2 + \Delta b^2\right)^{1/2}$$

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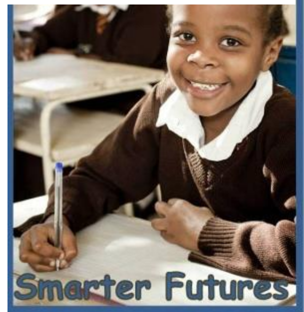
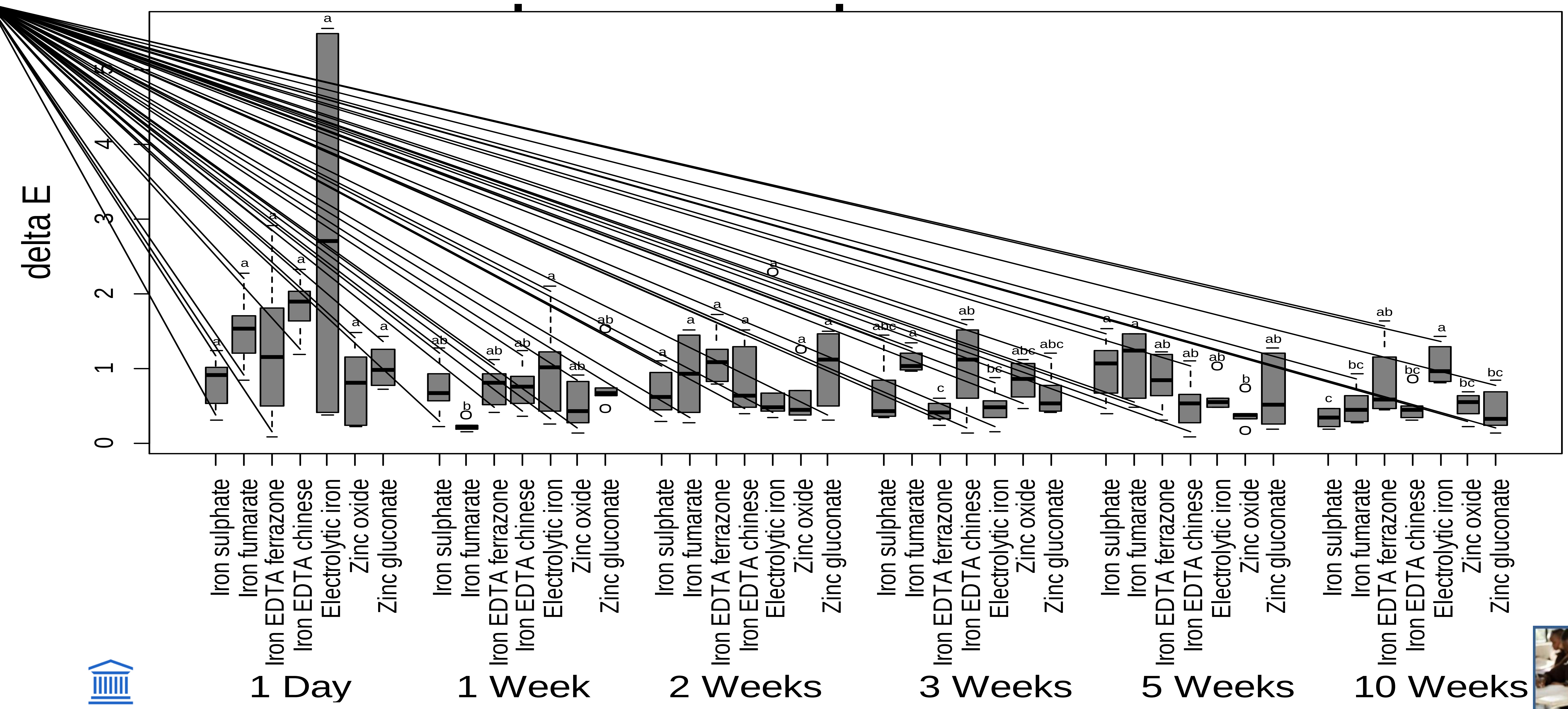


PART 1: RESULTS SUPER MAIZE MEAL



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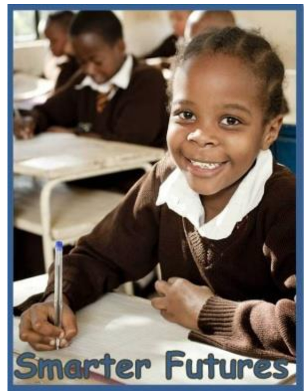
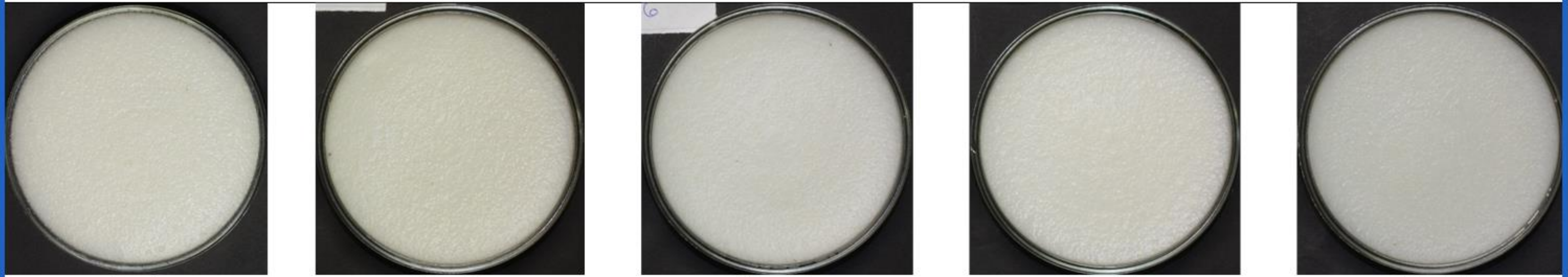


SUPER

Blank

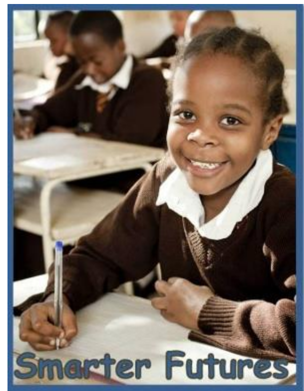


Day 1 | Week 1 | Week 2 | Week 3 | Week 5

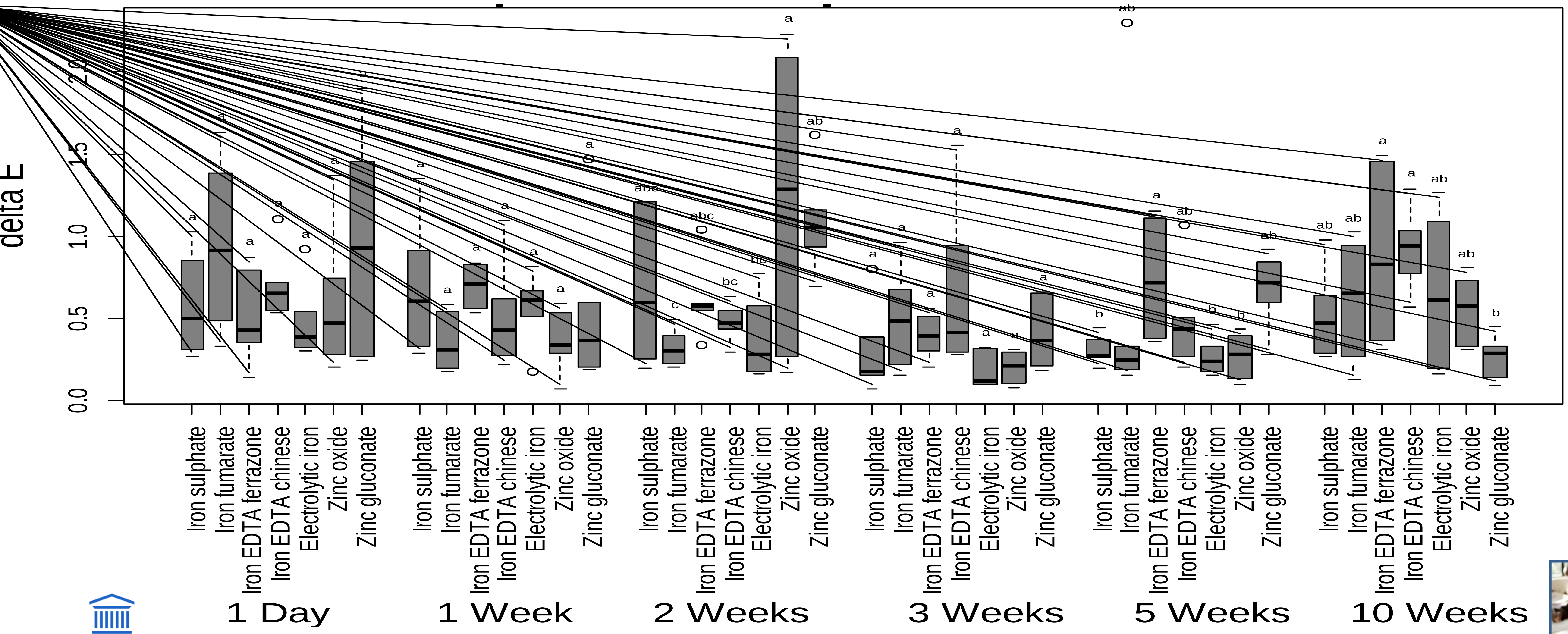
Iron EDTA ferrazone

Day 1 | Week 1 | Week 2 | Week 3 | Week 5

Iron EDTA chinese



PART 1: RESULTS SPECIAL MAIZE MEAL



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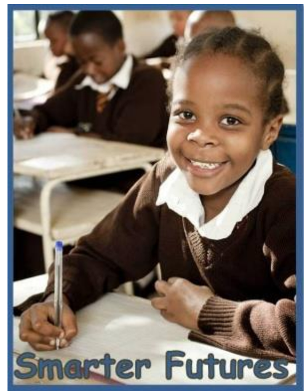

Blank


Day 1


Week 1


Week 2


Week 3


Week 5

Iron EDTA ferrazone


Day 1


Week 1


Week 2


Week 3


Week 5

Iron EDTA chinese


Day 1


Week 1


Week 2


Week 3


Week 5

PART 2: IMPACT OF WATER ON PORRIDGE COLOUR

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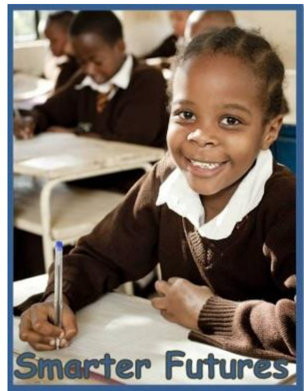
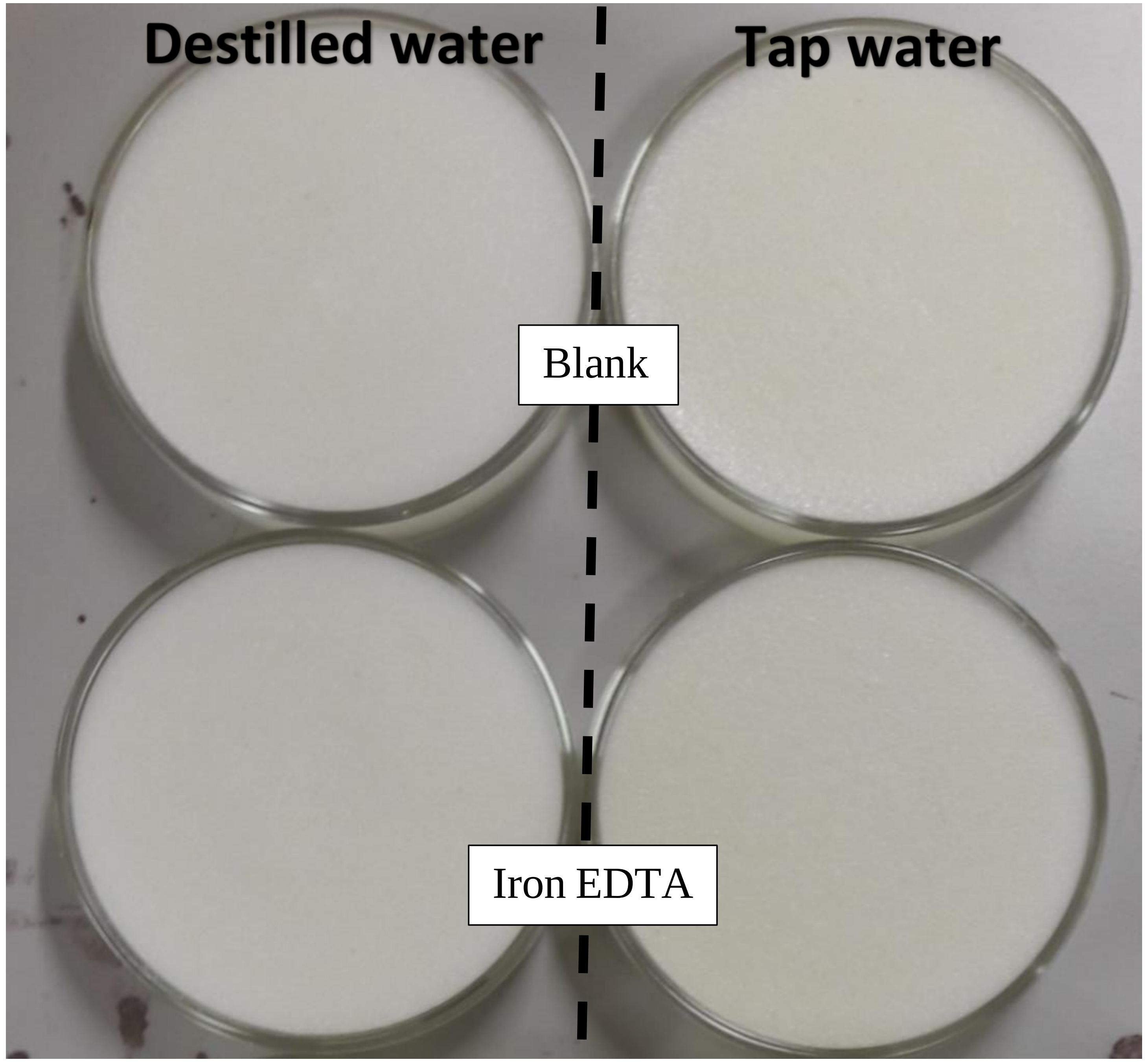
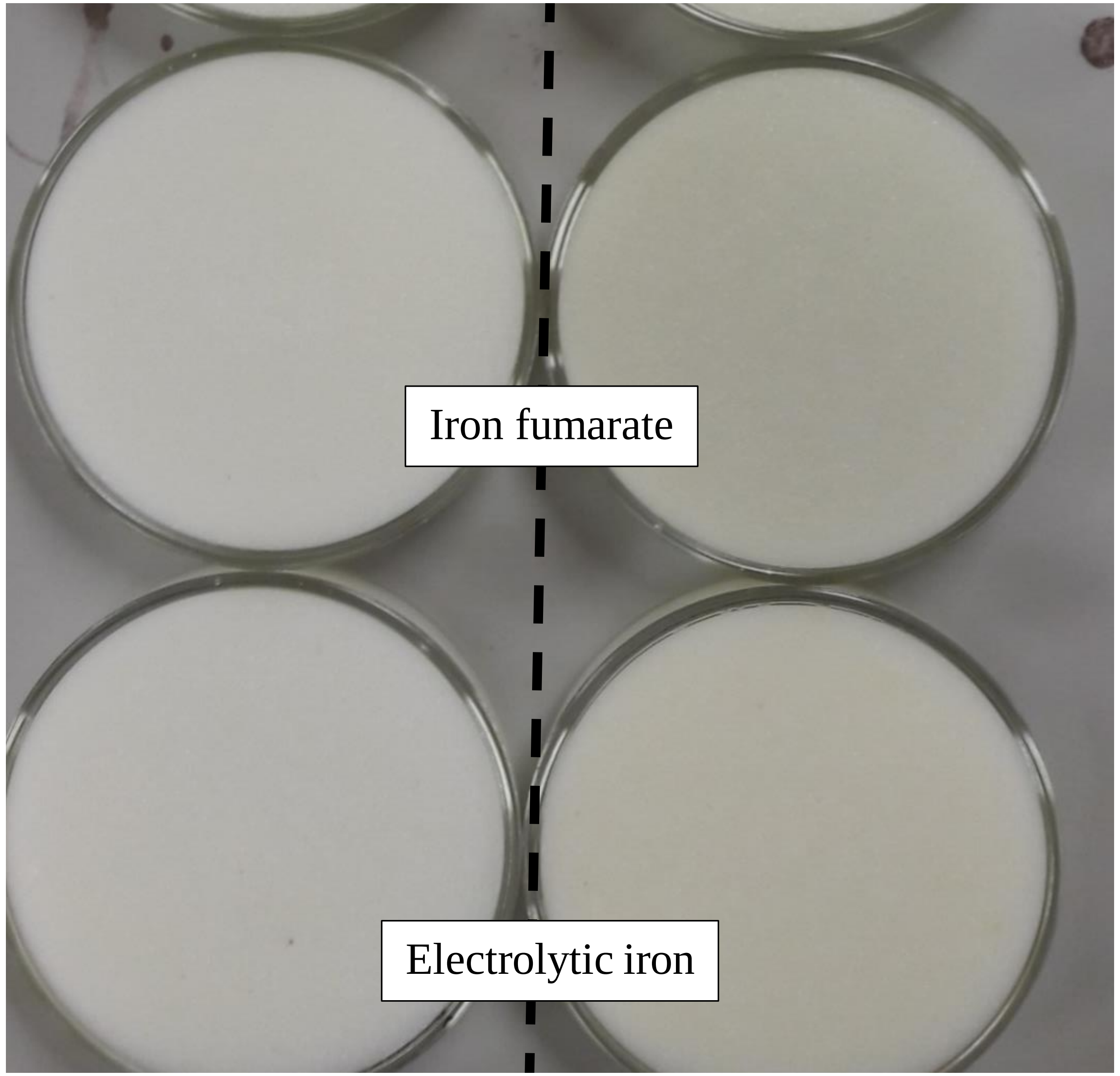


PART 2: RESULTS



Destilled water Tap water



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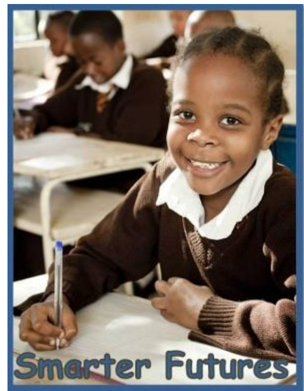
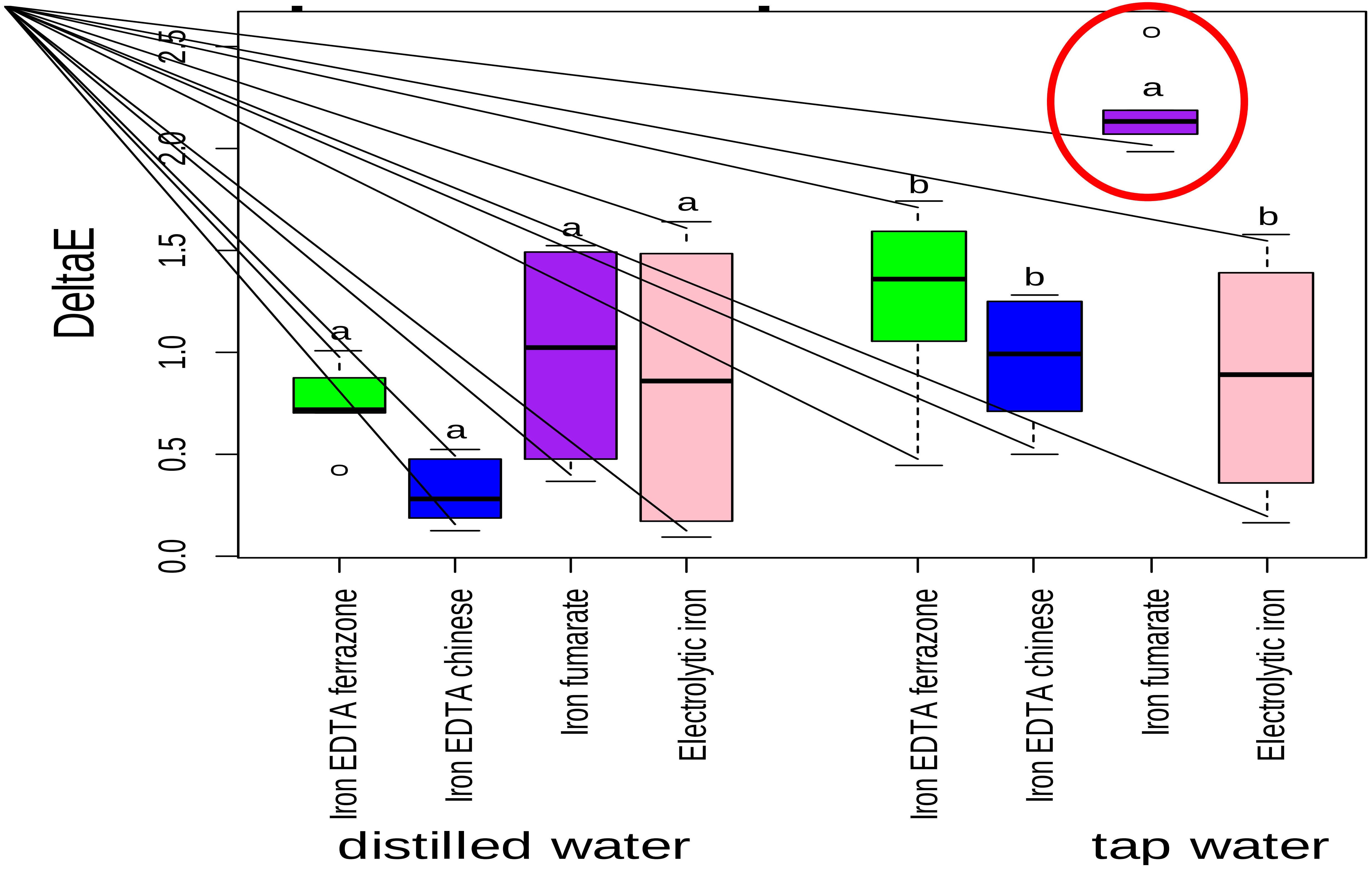


PART 2: RESULTS



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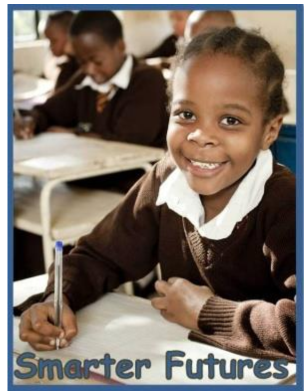

PART 3: IMPACT OF TYPE OF COOKING POT ON PORRIDGE COLOUR

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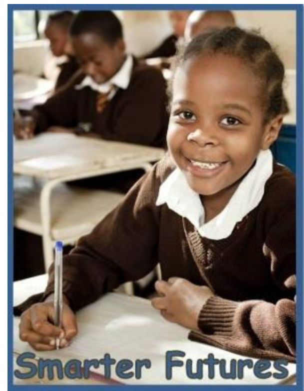


Special maize meal

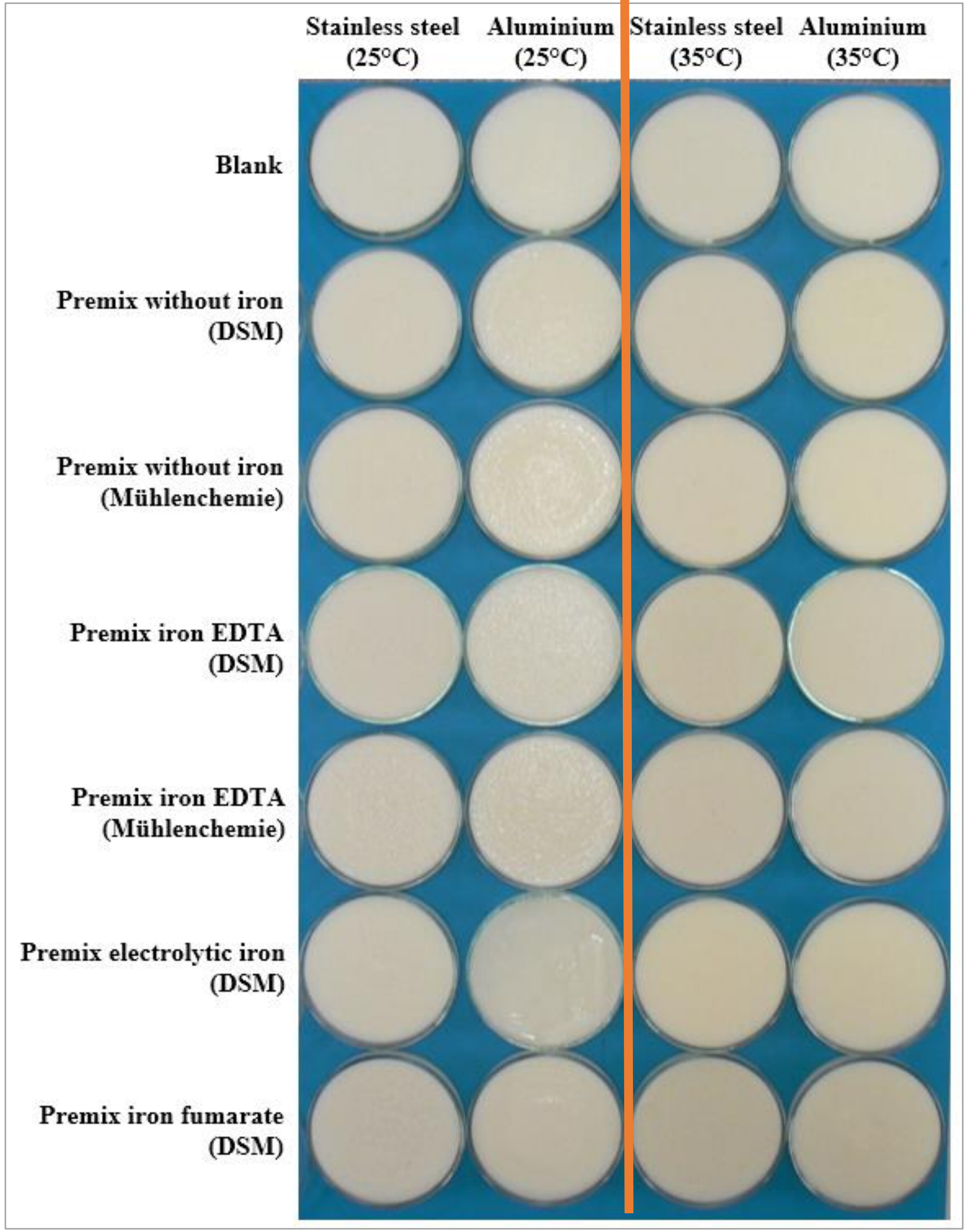
Full premixes

Storage at 25 and 35°C

10 weeks storage

Tap water

Two types of cooking pot



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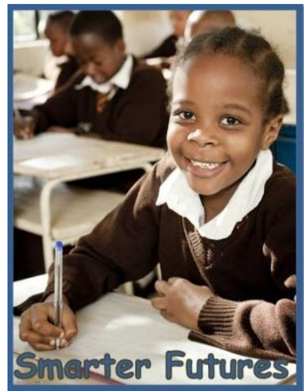

PART 4: DO IRON SOURCES ALTER THE SENSORY PERCEPTION OF MAIZE MEAL PORRIDGE?

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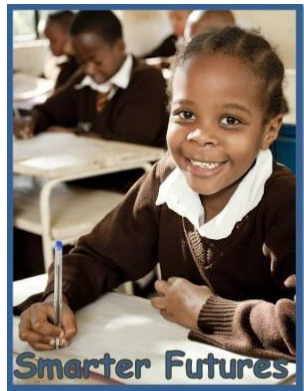

UGALI SCORE: KENYATTA UNIVERSITY, KENYA

Characteristic	Control	Ferrous fumarate	NaFeEDTA
Original samples			
Appearance	7.5 (0.7)	7.2 (0.8)	7.4 (0.9)
Color	7.8 (0.6)	7.2 (0.8)	7.6 (0.9)
Odor	7.1 (1.0)	7.0 (1.2)	7.2 (1.2)
Texture	7.4 (0.9)	7.1 (1.5)	6.9 (1.3)
Taste	7.1 (1.2)	6.7 (1.2)	7.3 (1.0)
Overall	7.5 0.7)	6.7 (1.2)	7.2 (1.0)
Retention samples			
Appearance	7.0 (1.3)	6.8 (1.3)	6.8 (1.3)
Color	7.2 (1.3)	6.7 (1.3)	6.6 (1.5)
Odor	6.7 (1.6)	6.3 (2.2)	6.5 (2.0)
Texture	6.7 (1.8)	6.9 (1.9)	6.9 (1.7)
Taste	6.7 (1.7)	6.8 (1.7)	6.3 (2.0)
Overall	6.4 (1.6)	6.5 (1.9)	6.5 (1.4)

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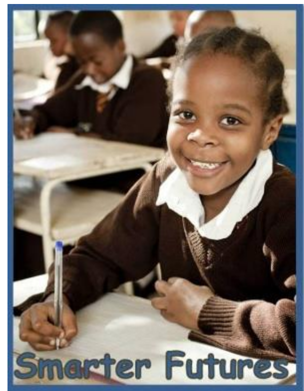

UGALI ACCEPTABILITY: KENYATTA UNIVERSITY, KENYA

Question	Control	Ferrous fumarate	NaFeEDTA
Original samples			
Is this product generally ACCEPTABLE?	1.2 (0.4)	1.1 (0.2)	1.1 (0.2)
Would you BUY this product if it was commercially available?	1.1 (0.3)	1.1 (0.2)	1.1 (0.3)
Would you BUY this product knowing it contained health benefits?	1.1 (0.3)	1.0 (0.0)	1.1 (0.2)
Retention samples			
Is this product generally ACCEPTABLE?	1.2 (0.4)	1.2 (0.4)	1.2 (0.4)
Would you BUY this product if it was commercially available?	1.2 (0.4)	1.2 (0.4)	1.3 (0.5)
Would you BUY this product knowing it contained health benefits?	1.1 (0.3)	1.2 (0.4)	1.1 (0.3)

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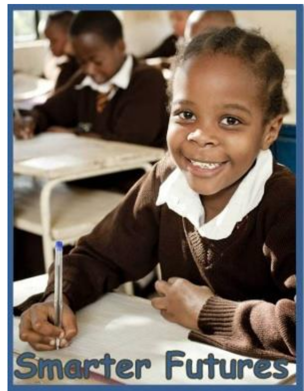

SENSORY TRIAL AT MAIZE FORTIFICATION MEETING, DAR ES SALAAM, TANZANIA

- 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

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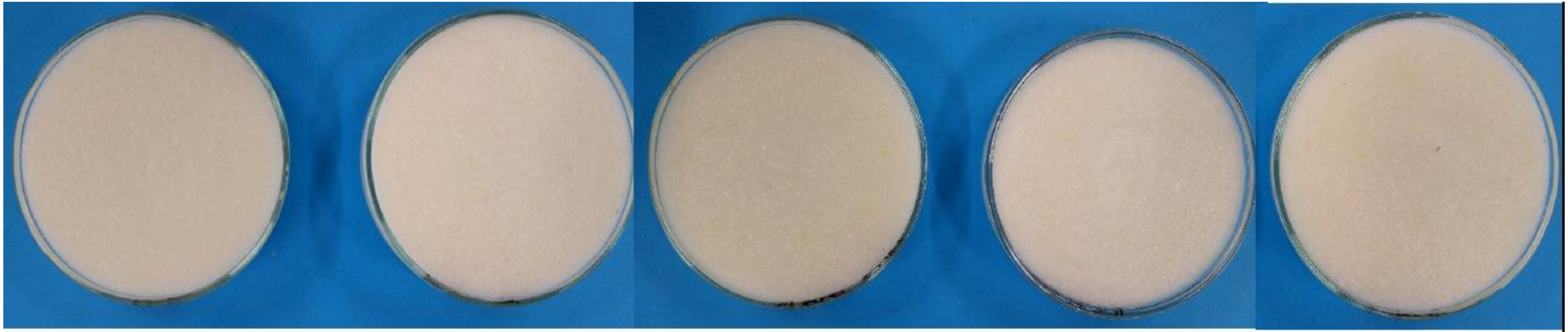
QUIZ: WHICH ONE IS FORTIFIED?

1 2 3 4 5



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Smarter Futures

CONCLUSIONS

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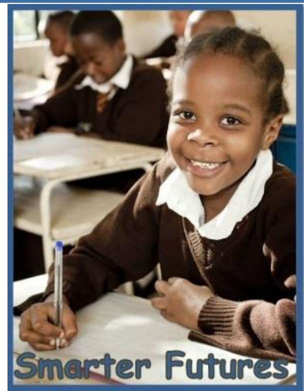

WHAT TO DO WHEN STARTING WITH FORTIFYING?

- Before starting up with fortifying -> check impact on product quality
- Make sure premix specifications (types, conc, quality…) are set right and clear from the beginning
- Use slightly higher concentrations (overdosage taking into account mill variation)
- Use in-land procedures and products
- Act smart: do we observe a difference? -> Is this difference acceptable

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