#7

Application of TXRF in Assessing Trace Elements in Formulated Indigenous Complementary Infant Flour

Kilavi P.K.[1*],, Maina D.M.[1], Gatari J.M[.1,] Wagner A.[2]

[1)] *Institute Of Nuclear Science and Technology, University of Nairobi*

[2)] *Department of Applied Physics, Chalmers University of Technology*

**corresponding author (pkageliza@yahoo.com)*

Introduction

Dietary trace elements are required for promotion of good health, growth and behavioral development of an infant. At the age of six months, breast milk cannot sufficiently meet the dietary trace elements requirements of an exclusively breastfed infant. As a result, complementary food which are relatively high in energy and nutrients density should be provided [1]. Furthermore, at the age of nine months these foods should be able to provide 97% of dietary iron, 86% of dietary zinc, 50% of dietary copper and 50% to 75% of dietary manganese [2].

Cereal based complementary infant foods do not provide most of the essential nutrients for growth and development of children. For instance, maize flour often fail to meet the nutritional needs of an infant due to its poor nutritive values [3]. Even though the use of cereal-legume based foods may be used to improve nutrient density and improved nutrient intake among the rural and poor urban infants, such plant based foods do not meet the total daily need of iron and zinc requirements for infants [1]. Nevertheless, when these legume-cereal base complementary infant foods are judiciously selected and combined in desirable pattern, then they could provide the essential nutrients including trace elements [4]. In this research, the levels of iron, zinc, copper and manganese in formulated indigenous complementary infant flour collected from selected rural areas in Kenya was evaluated. The bioavailability and daily intake of these elements was then estimated using data from literature.

Materials and methods

a. Sampling

A total of twenty eight (28) samples of complementary porridge flour for children between age of six (6) months and twenty four (24) months were collected from Sega, Turbo and Bomet region.

b. Sample preparation

Wet digestion in an open system using ANALAR nitric acid was used to extract the trace elements from the sample matrix. This analytical procedure was validated by subjecting certified reference material NIM-GBW 10017 to the same analytical procedure. For each digested sample, three aliquots were prepared. 100 µl of Ga as internal standard (2 ng μl^{-1}) was added to 100 µl of each aliquot and stirred. 10 µl of each sample was then pipetted onto a quartz carrier and dried on a hot plate at 60 ^{0}C for approximately 3 minutes.

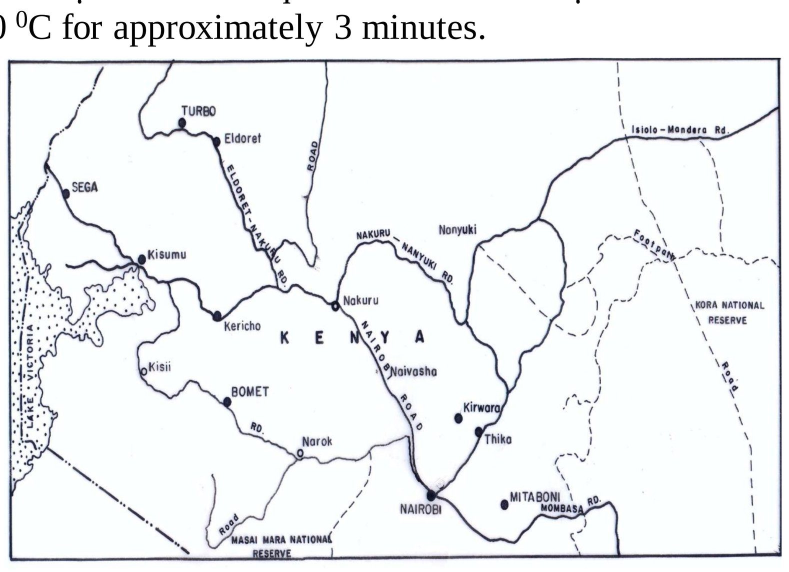


Fig 1: Sampling sites

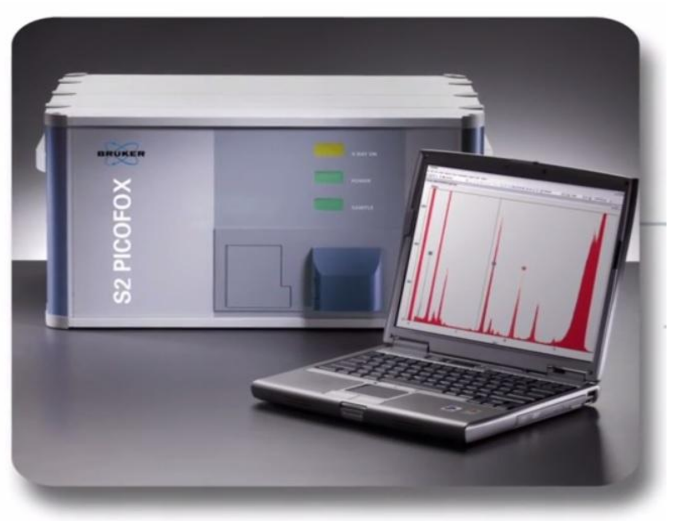


Fig 2: Experimental set-up

c. Experimental Set-up

Measurements were performed on a S2-PICOFOX TXRF spectrometer which operated at 50 kV, 1 mA and fitted with a Mo anode, Ni/C multilayer monochromator and Peltier cooled Si drift detector with a resolution of 145 eV at Mn K_{α} FWHM.

Results and Discussion

a. Validation of analytical procedure

The p-values at 95 % confidence level for elements of interest were greater that 0.05 . Therefore the experimental values were not significantly different from the certified values. In addition, the biases of the experimental valued from the certified values were below 10 % for all the elements of interest.

Concentration in mg kg $^{-1}$				
Element	Experimental (N =3)	Certified	P-Value	Bias
Mn	0.45 ± 0.15	0.51 ± 0.17	0.190	6.3
Fe	7.6 ± 3.5	7.8 ± 1.3	0.945	5.9
Cu	0.48 ± 0.06	0.51 ± 0.13	0.564	5.9
Zn	31 ± 4	34 ±2	0.307	8.8

Table1: Comparison of experimental and certified values of NIM GBW 10017, Milk Powder

b. Trace element concentration

The level of Mn, Fe , Cu and Zn varied significantly as shown in table 2.

Region		Label	Ingredients	Mn	Fe	Cu	Zn
Bomet	1	B1	Finger millet, Maize	174 ± 59	47.8 ± 14.8	3.27 ± 0.99	19.3 ± 6.4
	2	B2	Finger millet (Famila brand)	113 ± 2	44.6 ± 5.4	3.20 0.12	22.1 ± 0.7
	3	B3	Maize, finger millet and souring agent (Famila Brand)	35.7 ± 5.5	47.3 ± 2.5	1.95 ± 0.17	14.5 ±1.3
	4	B4	Maize, finger millet	132 ± 8	90.2 ± 7.2	1.56 ± 0.18	16.5 ± 0.5
	5	B5	Maize,	2.49 ± 0.28	15.8 ±1.8	0.78 ±0.05	15.7 ± 0.5
	6	B6	Maize	1.96 ± 0.39	14.6 ± 1.6	0.72 ± 0.02	14.3 ± 0.3
	7	B7	Maize and finger millet	167 ± 5	112 ± 3	3.41 ± 0.20	22.5 ± 0.8
	8	B8	Finger millet	329 ± 28	31.2 ± 4.5	2.49 ± 0.18	25.2 ± 2.4
	9	B9	Maize, finger millet	200 ± 42	37.6 ± 12.0	4.00 ± 0.25	26.4 ±0.6
Turbo	10	T1	Millet, soya, sorghum , maize	6.67 ± 0.03	158 ± 35	1.77 ±0.05	18.5 ± 0.3
	11	T2	Sorghum, soya, refined maize	6.83 ±0.14	126 ±7	2.15 ±0.19	20.1 ±0.4
	12	T3	Millet, sorghum, soya, cassava, groundnuts, refined maize, fish powder, milk powder, green grams	13.0 ± 4.3	150 ± 12	1.85 ± 0.10	29.6 ± 1.3
	13	T4	Maize	2.47 ± 0.14	28.8 ±4.9	1.82 ±0.13	36.2 ±1.7
	14	T5	Sorghum, finger millet, maize	46.5 ± 0.8	22.8 ± 3.2	1.55 ±0.02	21.0 ±0.6
	15	T6	Sorghum, finger millet, maize	78.1 ±2.0	74.4 ±1.8	2.17 ±0.07	22.0 ±0.2
	16	T7	Maize	11.2 ± 1.2	61.5 ±5.6	4.08 ± 0.25	81.2 ± 0.4
	17	T8	Maize, finger millet	73.2 ± 2.1	58.7 ± 4.5	2.39 ± 0.09	16.7 ±0.5
	18	T9	Maize	2.46 ± 0.15	17.7 ± 1.0	0.95 ± 0.02	17.2 ± 0.3
	19	T`10	Maize, Finger millet	46.2 ± 0.7	178 ± 20	2.17 ± 0.03	18.5 ± 0.2
Sega	20	S1	Maize, cassava, finger millet	33.8 ± 1.2	113 ± 5	2.15 ± 0.04	18.5 ±0.2
	21	S2	Maize, finger millet	46.2 ± 0.7	178 ± 20	2.17 ±0.03	18.5 ± 0.2
	22	S3	Groundnuts, soya, finger millet, sorghum, cassava	259 ± 1	246 ± 14	10.3 ± 0.3	49.0 ± 0.5
	23	S4	Soya, maize, finger millet	43.1 ± 1.6	202 ± 18	5.56 ± 0.21	66.1 ±2.0
	24	S5	Soya, maize, finger millet	60.7 ± 4.6	330 ± 60	3.75 ± 0.11	21.1 ± 0.1
	25	S6	Cassava, groundnuts, soya	38.2 ± 3.14	196 ± 34	11.0 ± 0.2	97.1 ± 4.4
	26	S7	Soya, sorghum, cassava	86.5 ± 0.6	376 ± 57	5.55 ± 1.04	24.6 ±1.0
	27	S8	Maize, sorghum, cassava	11.6 ± 0.7	85.0 ± 24.5	3.00 ± 0.39	68.5 ± 2.8
	28	S9	Sorghum, maize, cassava	22.2 ± 1.2	290 ± 93	3.99 ± 1.75	51.0 ± 6.9

Table 2: Mean concentration (mg kg^{-1} ± 1 SD) of Mn, Fe, Cu and Zn in samples collected from three regions of study.

Hierarchical cluster analysis was done to establish the similarity between the samples.

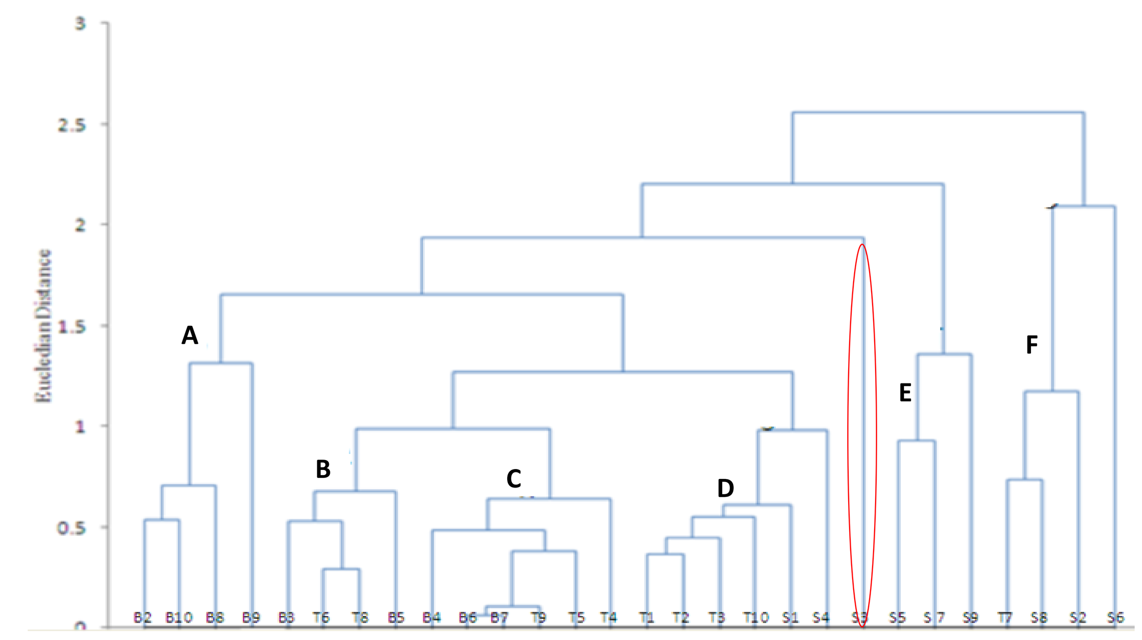


Fig 3: Hierarchical cluster analysis for the 28 samples

The clustering of the samples was dependent on the type of ingredients used, proportions of these ingredients in the samples and the origin of the sample.

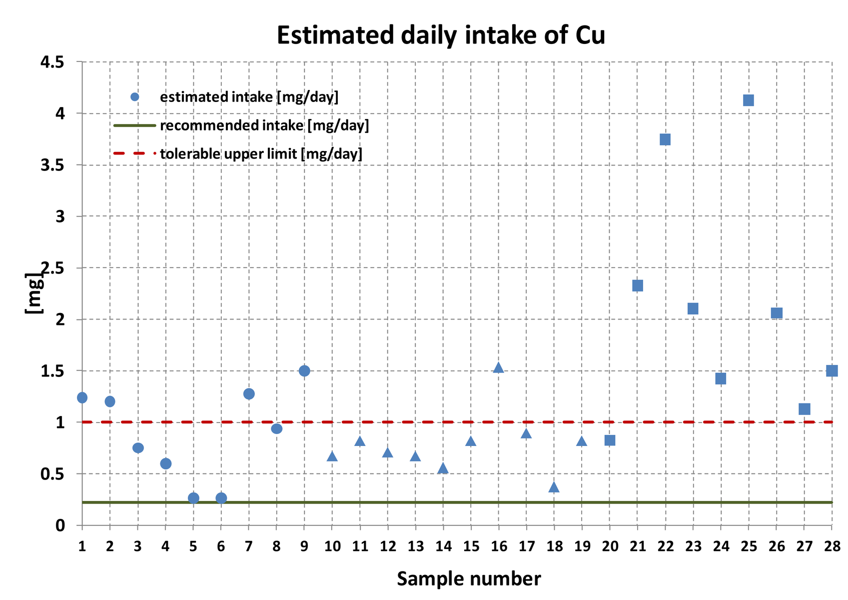
c. Estimation of daily intake of the trace elements

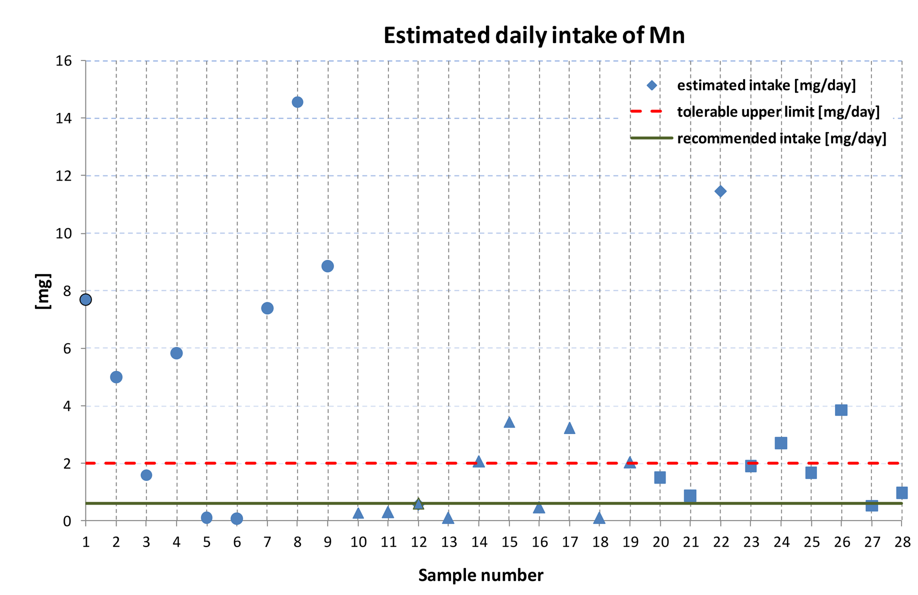
The daily intake of Mn, Cu, Fe and Zn from these indigenous complementary infant flour for infants aged 9-11 months was calculated based on Brown *et al [5]* assumptions that

i. Breast milk was of average volume and composition;
ii. Infants received three feedings of each complementary food per day as well as breast milk;

and on Gibson *et al* [1] assumptions that

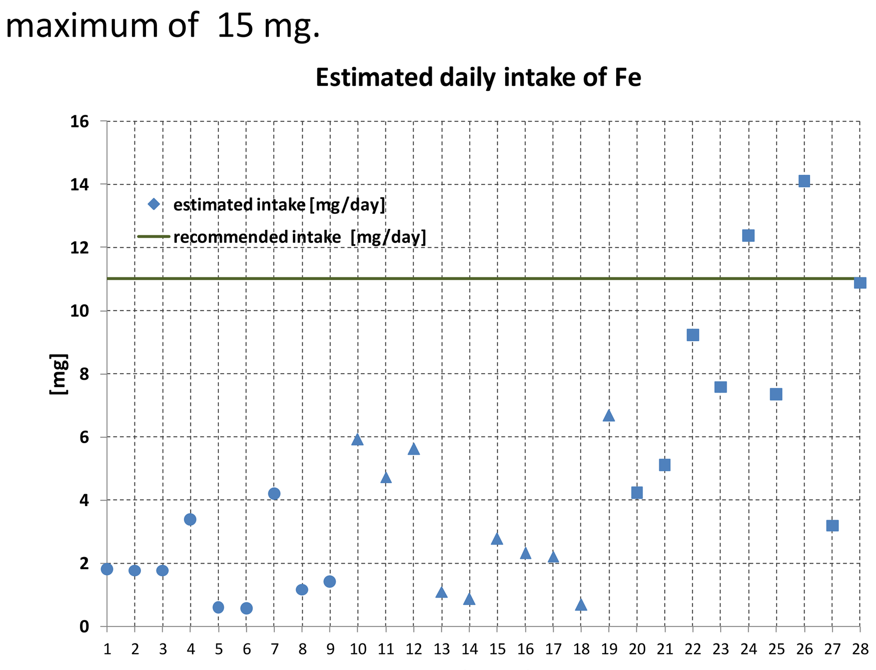
i. The amount of food consumed per feeding was 250g and infants received three feedings of complementary food per day;
ii. The complementary foods were able to provide 50% of the estimated need for Cu and Mn and 100 % of the need for Zn and Fe.

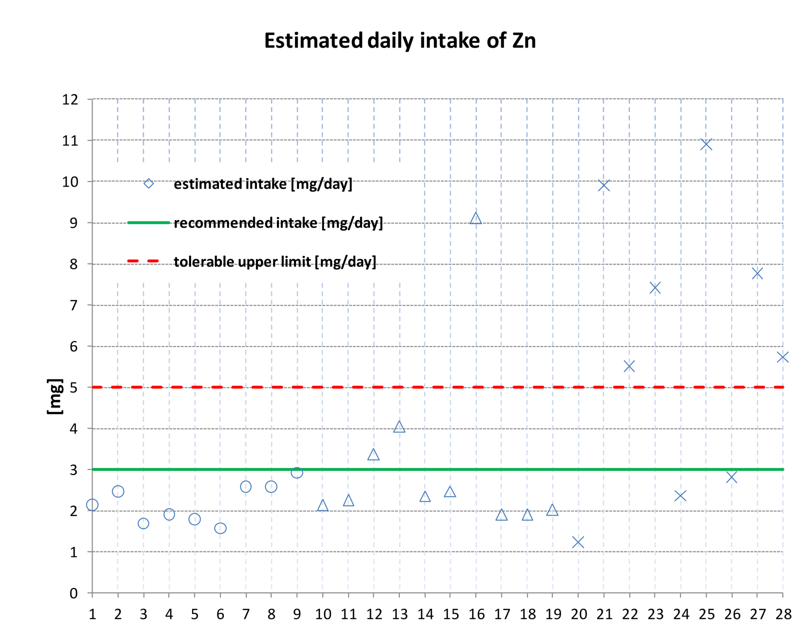




Copper concentration in eight out of the nine samples from Sega region exceeded the tolerable upper lint for infants aged 9 -11 months. Soy and groundnuts considered to be rich in copper [6] were some of the ingredients in these samples.

The concentration of manganese in most of samples that had finger millet as one of the ingredient were far much above the tolerable upper limit. The estimated daily intake of Mn was highest in samples from Bomet with a maximum of 15 mg.





Iron levels in most of the samples were below the recommended daily intake. However, samples from Sega which had Soya and/or groundnuts and considered to be a good source of iron [6] , as one of the ingredients had higher levels of Fe.

Zn concentrations were highest in samples from Sega, where the tolerable upper intake limit of 5 mg/day was exceeded in six out of nine samples. This samples had soya, considered to be good source of zinc [6].

Conclusion

This research shows that these indigenous complementary infant have a high potential to meet the requirements on recommended daily intake of Cu, Fe, Mn, and Zn, provide the individual ingredients are carefully selected and combined in desirable patterns.

Reference

[1] Gibson R.S., Ferguson E.I., Lehrfiedl J. (1998). Complementary foods for infant feeding in developing countries: their nutrient adequacy and improvement. *Eur J Cin Nutr*, **52**:764-770

[2] Melø R., Kristin G., Lars E., Tore S. (2008). Minerals and trace elements in commercial infant food. *Food Chemistry Toxicology* **46** :339-3342

[3] Lartey A., Manu A., Brown K.H., Peerson J.M., Dewey K.G. (1999). A randomized, community-based trial of the effects of improved, centrally processed complementary foods on growth and micro-nutrient status of Ghanaian infants from 6 to 12 months of age. *Am J Clin Nutr*, **70**:391-404

[4] Nnam N.M. (2001). Comparison of the protein nutritional value of food blends based in sorghum, bambara groundnut and sweet potatoes. *Infcrnufional Journal of Food Sciences und Nufrifion*, **52**: 25S-29S

[5] Brown K.H., Dewey K.G., Allen L.H. (1998), *Complementary feeding of young children in developing countries: a review of current scientific knowledge*,WHO/UNICEF

[6] Andersen I.T., Acham H., Maage A., Malde M.K. (2011). Iron and Zinc content in selected foods in the diet of schoolchildren in Kumi district, East of Uganda: a cross sectional study. *Nutrition Journal*, **10**:81

Acknowledgment

National Commission of Science, Innovation and Technology (NACOSTI) and International Science Program (ISP) for funding the corresponding authors' MSc. study at the Institute of Nuclear Science and Technology, University of Nairobi.