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A Critical Evaluation of Survey Results of Vitamin A and Fe Levels in the Mandatory Fortified Food Vehicles and Some Selected Processed Foods in Nigeria

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ABSTRACT

A nationwide survey was conducted to ascertain the levels of Vitamin A and Fe in wheat and maize flours, sugar and vegetable oils and some flour-based processed foods to assess compliance to the Nigerian Industrial Standard. Samples were collected from factories and markets in all the 36 states of the six geopolitical zones of the country; comprising 94 (vegetable oil), 42 (sugar), 95 (flour) and 62 (processed foods) and subjected to vitamin A and iron analyses using HPLC and AAS respectively. Using a 50% acceptable range of the specified minimum standards as basis for compliance, the results showed that only 14.9 – 20.2 % of the samples of vegetable oils analyzed fell within acceptable level (10,000-20,000 IU/kg) but there was no significant difference ($p > 0.05$) in the results obtained for the six zones. For sugar, only 11.9 – 16.7 % of the samples collected complied with the acceptable range of the standards (12,500 – 25,000 IU/kg) but this varied significantly ($p > 0.05$) with the zones. The levels of compliance for vitamin A and Fe in flours were found to be 12.2 – 33.3 % and 1.0 – 21.0 % respectively at the acceptable range of 15,000 – 30,000 IU/kg and 34.6 – 46.8 mg/kg, respectively. In all cases, the compliance levels at the 50% range were only marginally higher than at the 30% WHO acceptable range. For the levels of these micronutrients in the processed foods, the values obtained ranged between 5,139 – 7,687IU/kg for vitamin A and 11.9 – 16.7 mg/kg for Fe. These results call for a critical and holistic review of the fortification strategy in Nigeria.

Keywords: Fortification, compliance, vitamin A, iron, flour, vegetable oils.

Introduction

Nigerian industries have been voluntarily fortifying staple foods since the 1990s. Mandatory fortification of wheat and maize flour, edible vegetable oil and sugar was enacted in February 2000 and enforcement began in September 2002. However, fortification levels have been observed not to be consistent and coverage is not universal (Anon, 2003). A survey conducted in October 2003 by NAFDAC that sampled flour and vegetable oils from the distribution chain for laboratory assessment of vitamin A levels indicated only 5 per cent compliance (Akinyele, 2009).

For several years, the Global Alliance for Improved Nutrition (GAIN) have been supporting the National Food Fortification Programme through collaboration with the National Fortification Alliance, the National Agency for Food and Drug Administration and Control (NAFDAC) and Standards Organisation of Nigeria (SON) in the mandatory fortification of wheat and maize flours with vitamin A, B vitamins and iron, as well as vegetable oil and sugar with vitamin A only. Funding was provided to assist in achieving increased compliance to existing legislation and to create the necessary awareness to increase production and consumption of fortified foods, conduct a

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consumer awareness campaign around fortification and enable monitoring and impact evaluation activities. As stated by the World Bank, 'probably no other technology available today offers as large an opportunity to improve lives and accelerate development at such low cost and in such a short time' as fortification, along with other interventions to control micronutrient deficiencies (World Bank, 2006). Unfortunately, available evidence shows that Nigeria still has one of the highest rates of under-5 and maternal mortality in the world (respectively 142.9 and 93 per 1,000 in 2008) (Mundi Index, 2013) with vitamin A deficiency (VAD) being a major contributory factor. In addition, several non-national representative studies have highlighted the high prevalence of anaemia and vitamin A deficiencies in Nigeria. For example, Aaron *et al.* (2011) and Akinyele (2009) showed that 35.9% of their primary school children were anaemic, 11.6 iron deficient and 15.9% vitamin A deficient. Among pregnant women in the south-eastern region of Nigeria, only 35.6% had adequate vitamin A status while the rest were deficient (Williams *et al.*, 2011). According to the WHO/FAO guidelines (Allen *et al.*, 2006), iron and vitamin A deficiency can still be considered as public health problems.

This study was therefore aimed at providing updated information on the actual current levels of the Vitamin A and Iron in the mandatory vehicles, namely cereal flours, vegetable oils and sugar and some selected processed foods. This is with a view to identifying the challenges and sustainability issues in support of the ongoing efforts to strengthen the national food fortification programme.

Materials and Methods

Food sampling and collection

For the sampling procedure, the six zonal Nigerian administrative structure was used as follows: (i) South West (including the states of Ekiti, Lagos, Osun, Ondo, Ogun, Oyo); (ii) South East (Abia, Anambra, Ebonyi, Enugu, Imo); (iii) South South (Akwa Ibom, Bayelsa, Cross River, Delta, Edo, Rivers); (iv) North Central (Benue, Kogi, Kwara, Nasarawa, Niger, Plateau, FCT Abuja); (v) North East (Adamawa, Bauchi, Borno, Gombe, Taraba, Yobe); and (vi) North West (Kaduna, Katsina, Kano, Kebbi, Sokoto, Jigawa, Zamfara). Throughout the six administrative zones, the food samples were collected from industries and major markets located in the two major towns/cities in each of the states surveyed as described in Table 1.

Table 1: Distribution of samples sourced by administrative structures

Province	Total number of samples of vegetable oil	Total number of samples of cereal flours	Total number of samples of sugar
South West	15	17	6
South East	16	23	4
South South	18	16	4
North Central	18	14	11
North East	14	13	7
North West	17	11	9
Total	98	94	41

Each of the samples collected was removed from their original packaging. The samples were packed in high moisture barrier zip lock pouches for cereal flours and sugar, but in dark bottles for vegetable oils with retention samples stored in a chest freezer. A comprehensive database of information was prepared for the samples. The following information was recorded for each sample: (i) date of sampling, (ii) name and address of sample source, (iii) type of product (i.e. cereal flours (including wheat flour, semolina and corn flour), sugar, vegetable oil and processed food), (iv) brand name, and (v) sample code for identification of individual samples. The database was also used to record the analytical results for the samples. However, the laboratories only received the coded samples and did not know the origin of the samples.

Laboratory analysis

It was essential for the successful outcome of the investigation that accurate and reliable laboratory analysis of the samples be ensured. It was decided to make use of one university in Nigeria (Central Multipurpose Research Laboratory, University of Ibadan) and an external laboratory from South Africa, the Southern African Grain Laboratories (SAGL) in Pretoria (http://www.sagl.co.za/).

For each sample a 2 kg portion was submitted to each laboratory. Each sample was kept in amber bottles or zip lock bags (colour and air-tight) placed in paper board boxes to prevent the effect of the factors (light and air) that can lead to loss of the target micronutrients. All samples for SAGL were then shipped to Johannesburg through FEDEX, a certified courier company and, simultaneously, another set delivered to the Central Multi-Purpose Research Laboratory of the University of Ibadan (CMRL,UI) for the analyses.

Determination of vitamin A in cereal flours, vegetable oil and sugar

Determination of vitamin A in flours, vegetable oil and sugar were carried out using the same procedure as described by Ashoor and Knox, 1987 for both SAGL and University of Ibadan (CMRL, UI) samples. Five grams of samples were saponified with 5.7 N alcoholic KOH for 45 min and then extracted with diethyl- and petroleum ether. The vitamin A as retinol is analysed by reverse phase HPLC at 327 nm using a UV detector. The standard used was dry vitamin A Palmitate (250 CWS/F) from Chempure for SAGL (http://www.chempure.co.za/). With each set of samples, an in-house quality control sample was included; the sample was an AACC VMP proficiency sample. For sugar and cereal flour samples, a 100 g sample was dissolved in 100 ml water and a subsample of 6.25 g was analyzed according to the previous methodology summary.

Determination of iron in cereal flours

The same method of analysis was also used by SAGL and CMRL, UI in the determination of Fe in flours. This method determines total iron (Fe) by flame atomic absorption (AA) at 248.3 nm after the wet digestion and filtration of 0.5 g samples. Wet digestion of samples solubilizes inorganic elements, including iron. The iron-containing solution is then atomized in an air-acetylene flame and the absorption is measured at a specific wavelength to determine the concentration of the elements such as Fe. A control sample (from http://www.smminstruments.co.za for SAGL) and blanks were included in each set of samples.

Standard used as reference

In this study, fortification levels for each of the food vehicles used to test the compliance were set according to the current national standards. An acceptable range of 50% was used to determine if the level of fortification was adequate (given additional factors such as premix quality and stability, in-process addition challenges) when compared with the World Health Organization (WHO) guidelines of an acceptable range of 30% due to losses during distribution and storage. Table 2 presents the current regulations and the range used. To estimate current fortification premix costs for each programme, price data as of November 2012 from the Global Alliance for Improved Nutrition (GAIN) Premix Facility were used.

Statistical analysis

Data entry, management and analysis were performed with Excel 2007™. Qualitative variables were expressed as percentages and standard error percentage. Continuous variables were expressed as arithmetic means and standard error of the mean. Additional analysis was performed through SPSS 20™ such as association between prevalence and region was assessed using univariate logistic regression models (surveylogistic procedure). Association between continuous variables and region was assessed using univariate linear regression models (surveyreg procedure). The first type error rate was set at 0.05.

Results

Table 1 shows the distribution of samples collected across all the six geographical zones and the Federal Capital Territory. Based on the 30% loss acceptable under current WHO guidelines (Table 2a), only 24.2% compliance is recorded out of the 94 samples of vegetable oils collected (Figure 1). However, from Figure 6, only 14.9% to 20.2%) were within the 50% acceptable range [10,000 – 20,000 IU/kg] (Table 2b) with 11.7% to 14.9% above 20,000 IU/kg, and 68.1% to 70.2% under 10,000 IU/kg. For both laboratories, there was no difference between the zones and between imported versus local vegetable oils ($p > 0.05$). Figure 2 also shows that the percentage of vitamin A compliance in sugar is only 26.2% based on WHO guidelines. From Figure 7, the same trend of compliance was observed as only 11.9% to 16.7% of the 42 samples collected were compliant based on the 50% acceptable range [12,500-25,000 IU/kg]. More than two-thirds of the samples were under 12,500 IU/kg (66.7% to 83.3%). However, a significant difference was observed between the zones according to the SAGL data. In the North West and North East, the mean levels (respectively 3,966 IU/kg and 2,973 IU/kg) were significantly lower ($p = 0.02$) than the other zones (South West: 15,136 IU/kg; South East: 14,986 IU/kg; South South: 17,051 IU/kg; North Central: 13,332 IU/kg).

Figure 3 shows the percentage compliance of vitamin A in cereal flours to be only 10.2% based on the WHO guidelines. This figure is observed to be much lower than for vegetable oils and sugar, probably because of the contribution of flours other than wheat, particularly maize flour and semolina which do not appear to be fortified at all. Out of the 95 flour samples, Figure 8a shows that only 12.2 – 33.3% were compliant at the 50% acceptable range for vitamin A [15,000-30,000 IU/kg]. Figure 4 shows the percentage compliance for iron in cereal flours to be 37.8% based on 15% losses expected according to WHO guidelines. However, based on an acceptable range of 50% loss for iron [34.6 – 46.8 mg/kg], Figure 8b shows that compliance ranged from 1 – 24% for various cereal

Table 2a: Compliance basis for micronutrient fortification (as adapted from WHO Food Fortification Guidelines)

Food	Nigeria Industrial Standard (NIS)	Losses during distribution & storage (%)	Feasible Fortification Level/Range (FFL)
Vitamin A (IU/KG)			
Sugar	25,000	30	25,000 - 17,500
Oil	20,000	30	20,000 - 14,000
Flour	30,000	25	30,000 - 22,500
Iron (mg/Kg)			
Flour	40.7	15	40.7 - 34.59

flours. Table 3 shows the mean iron levels in flours across the six zones while the distribution of iron by flour types is shown in Table 5. Table 4 shows the median fortification levels in Nigeria based on SAGL data as this is a reference laboratory.

Table 2b: Current NIS standards versus Modified WHO recommendation for compliance

	Current National Standard*	Acceptable compliance range for vitamin A**	Acceptable compliance range for iron**
Cereal flour	30,000 IU/kg of vitamin A (As palmitate), 40.7 mg of iron, 3.7 mg of riboflavin (Vitamin B6), 6.2mg of thiamine and 49.5 mg of niacin	30,000 – 15,000 IU/kg	40.7 – 34.6 mg/kg
Vegetable oil	20,000 IU/kg of vitamin A (As palmitate)	20,000 – 10,000 IU/kg	–
Sugar	25,000 IU/kg of vitamin A (As palmitate)	25,000 – 12,500 IU/kg	–

Note: *Source: National Fortification Alliance (NFA)/National Agency for Food and Drug Administration and Control (NAFDAC), 2010.

**The above suggested modified recommendation on acceptable range is based on an assumption of a higher loss rate than the WHO guidelines if other local factors are taken into account. It is set at 50% loss for vitamin A and 15% loss for iron, to take care of additional losses (see Table 2a above) due to probable variations in premix quality and in-process losses at factory level.

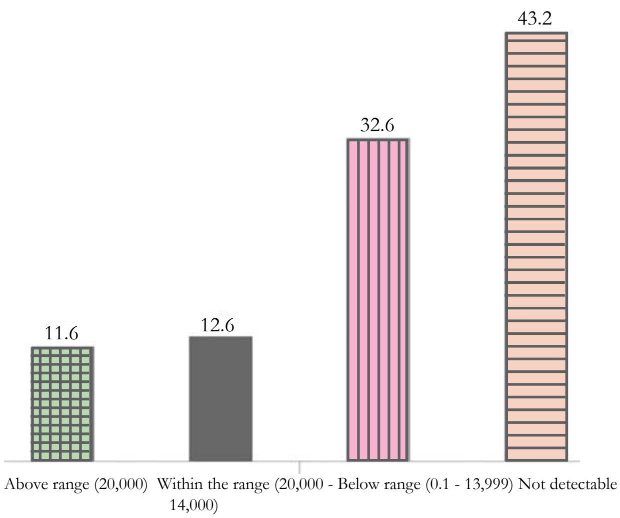


Fig. 1: Percentage of vitamin A compliance in vegetable oils

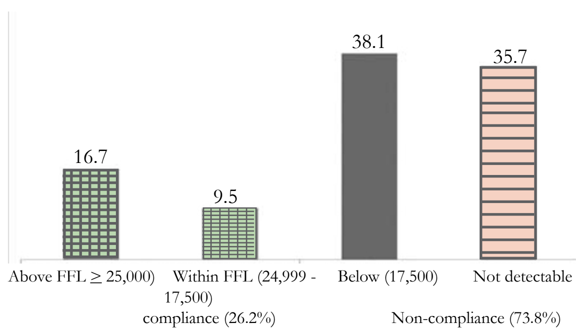


Fig. 2: Percentage of vitamin A compliance in sugar

A significant difference was observed between the laboratories with the University of Ibadan laboratory (CMRL) data consistently having lower means than SAGL (respectively 6,642 IU/kg versus 12,374 IU/kg for vitamin A, $p = 0.029$; and 15.3 mg/kg vs. 33.3 mg/kg for iron, $p < 0.001$). No

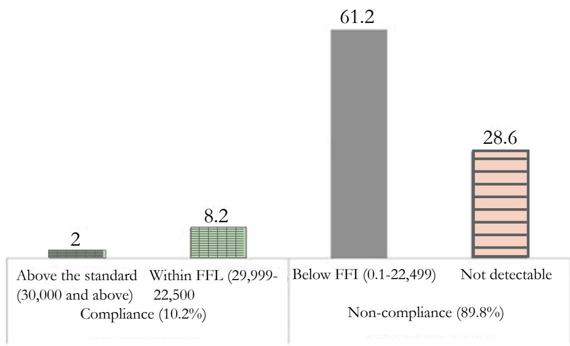


Fig. 3: Percentage of vitamin A compliance in cereal flours

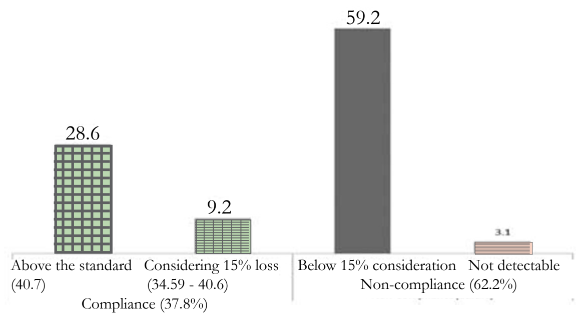


Fig. 4: Percentage of iron compliance in cereal flour

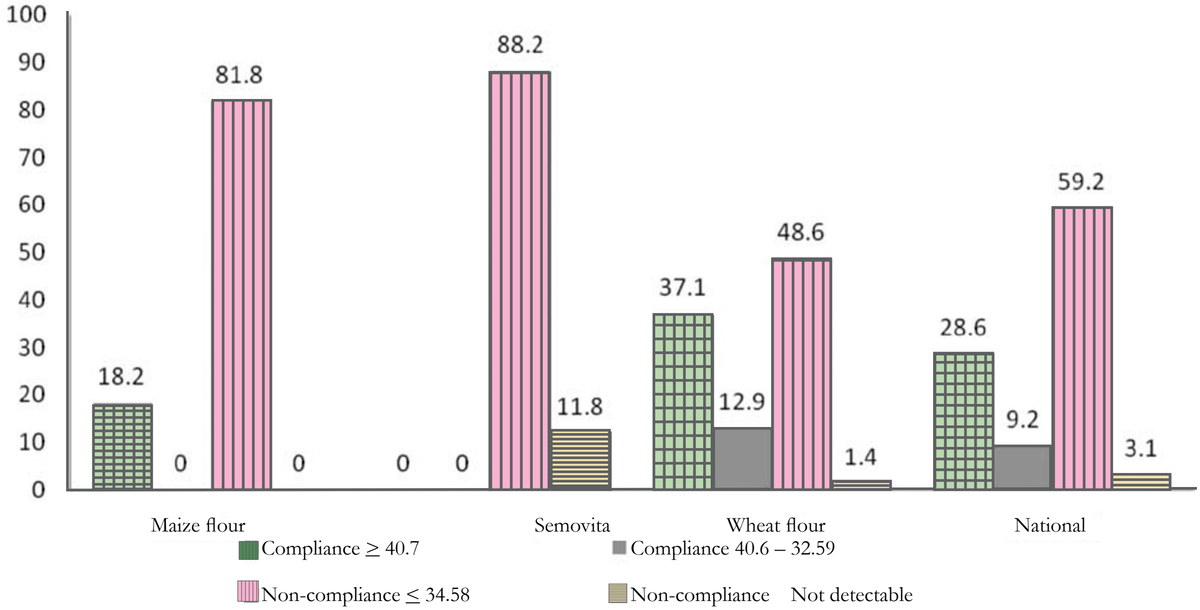


Fig. 5: Percentage of iron compliance in cereal flour by types

difference between the zones was observed for vitamin A ($p > 0.05$) while the differences were significant for iron (Table 3).

Using the estimated national consumption per capita of 50 g of cereal flours, 19.2 g of refined sugar and 18.5 g of vegetable oil, and the median fortification level (Table 4), women of reproductive age will increase their intake of vitamin A from 303.5 to 461.7 IU/kg (depending on the laboratory) and of iron from 0.7 to 1.3 mg which represent respectively 25.5 to 38.8% of the Estimated Average Requirements and 2% to 4% of the Recommended Nutrient Intake. Table 5 also shows that processed foods (instant noodles, bread, biscuits) using fortified staples and vegetable oils contain higher levels of vitamin A and iron.

Discussion

From the foregoing results, it is evident that the low compliance of the samples of mandatory vehicles limits the projected impact of the current Nigerian fortification strategy. During these analyses, it was observed that several samples were without any

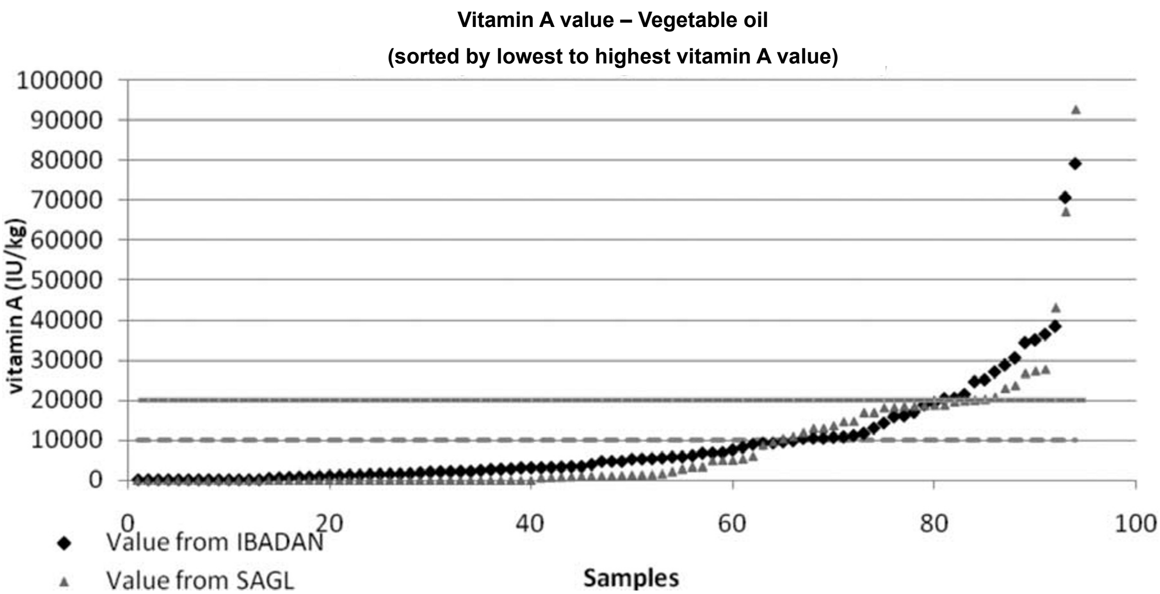


Fig. 6: Vitamin A values for vegetable oil

Note: The horizontal line represents the Nigerian standard at 20,000IU/kg and the limit of acceptability if 50% of losses are taken into account is represented by the horizontal broken line.

traces of vitamin A and iron. Despite the fact that fortification is mandatory for sugar, vegetable oil and cereal flours, the high levels of specified standards might be one of the factors encouraging low compliance.

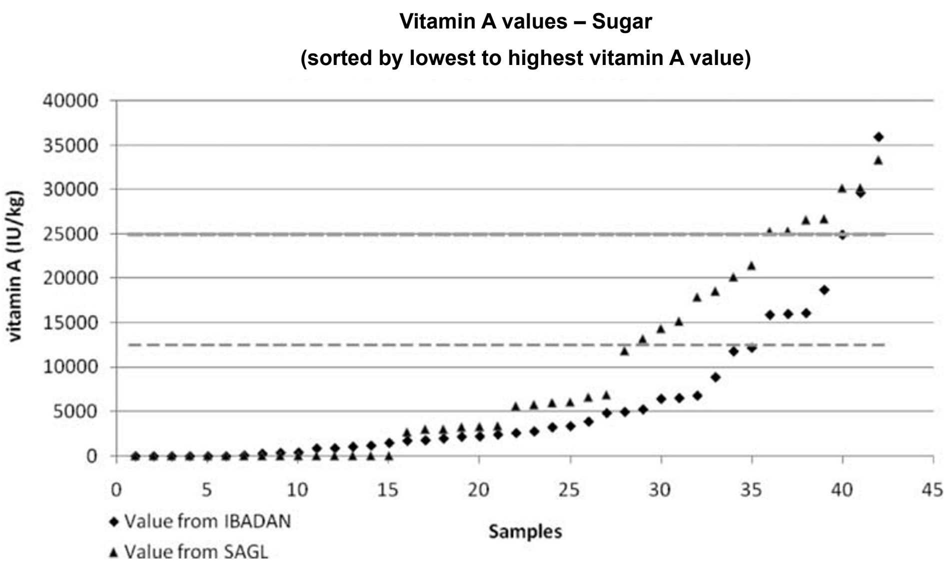


Figure 7: Vitamin A values for sugar

Note: The lines represent the Nigerian standard at 25,000IU/kg and the limit of acceptability if 50% of losses are taken into account.

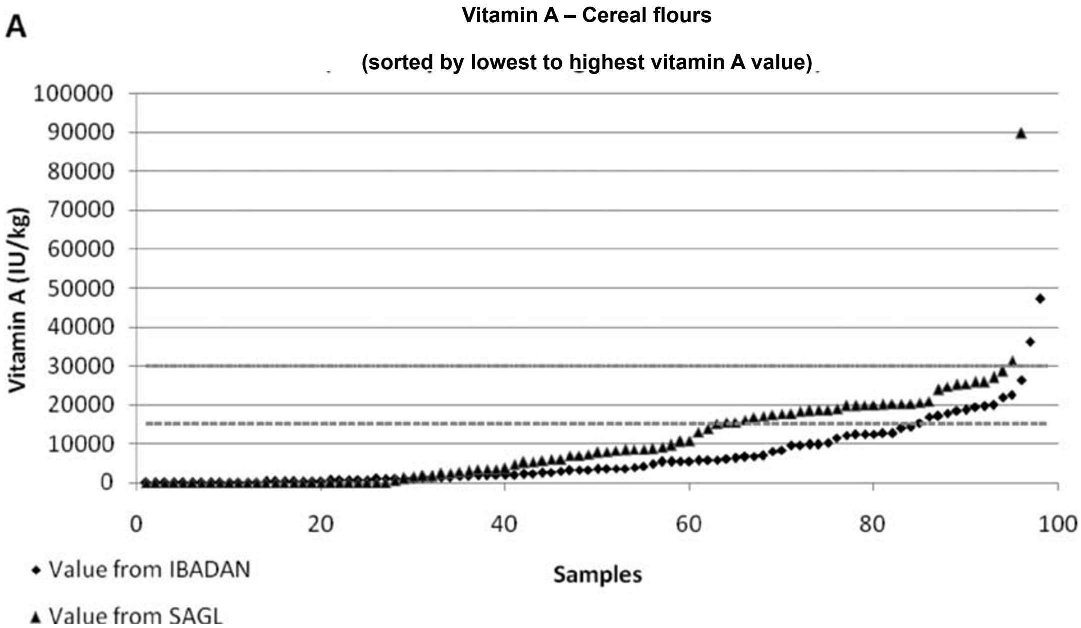
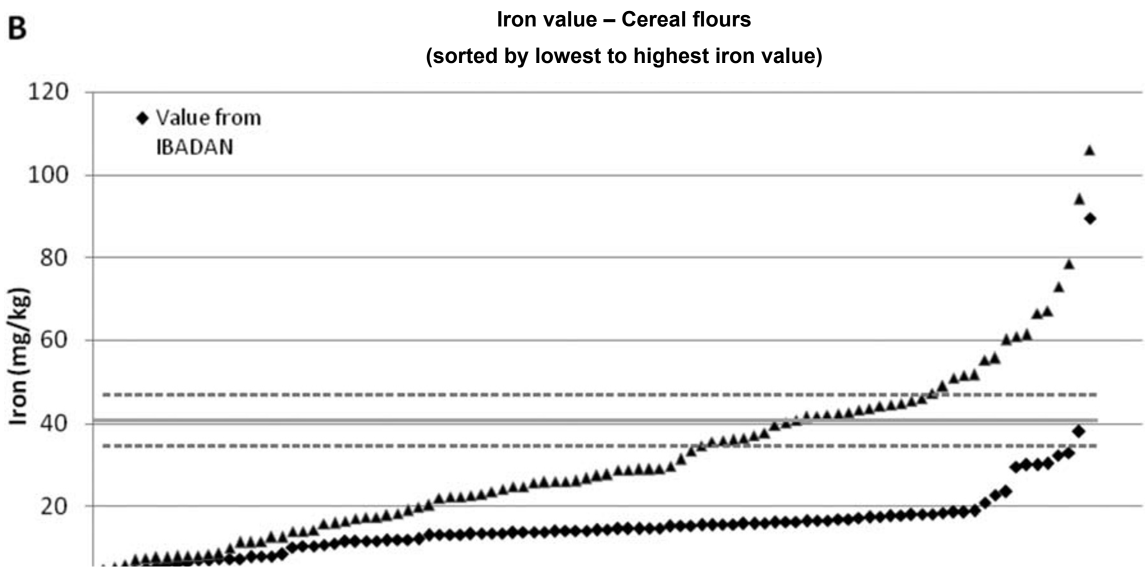


Fig. 8A & 8B: Vitamin A values (A) and iron values (B) for cereal flours

Note: The horizontal line represents the Nigerian standard at 30,000IU/kg and the limit of acceptability if 50% of losses are taken into account is represented by broken line.



Note: The horizontal straight line represents the Nigerian standard at 40.7mg/kg and the limit of acceptability ±15% of the standard is indicated by horizontal broken line.

Table 3: Mean iron levels in flours across administrative zones

Administrative	Iron content (mg/kg) ex-SAGL
South West	54.8 ± 50.9
South East	22.3 ± 11.1
South South	29.3 ± 19.0
North Central	27.2 ± 15.4
North East	36.5 ± 21.2
North West	30.4 ± 12.7
P (ANOVA)	0.007

Table 4: Median fortification levels in Nigeria (based on SAGL data)

Food vehicle	Vitamin A content (IU/kg)	Iron content (mg/kg)
Vegetable oil	11,41.5	-
Sugar	4,486.0	-
Wheat flour	7,089.5	27.4

Table 5: Content of vitamin A and iron in processed foods (mean ± standard of the mean; median)

Processed foods	Vitamin A content (IU/kg)	Iron content (mg/kg)
Noodles (n = 18)	7687.1± 1863.0 (5900.0)	11.9±0.6 (11.7)
Biscuits (n = 33)	5381.7±587.4 (5870.0)	16.7±0.7 (16.1)
Bread (n = 11)	5139.2±1249.6 (5440.0)	15.4±1.7 (16.4)

For wheat flour, national programmes aim to add all the micronutrients lost during the process and this is increasing the cost of the premix. Aaron *et al.* (2012) showed that countries such as Nigeria have to spend approximately 1.2 US$/MT (excluding the cost of vitamin A) to achieve this objective. Adding vitamin A to such a premix can increase the cost drastically to more than 5 US$/MT (Nutrition GAfI, 2012). This significant cost would ordinarily appear to be a burden to industry without any incentives, which may be why many of them do not fortify adequately. With an annual consumption of approximately 1.2 million MT of wheat flour, the industry will need to invest more than 6 million USD per year. It is therefore important to maximize the benefit of this cost to ensure both impact and sustainability. Unfortunately, the current premix includes only electrolytic iron which is not in line with the WHO guidelines for a daily consumption of less than 75 g/capita/day (WHO, UNICEF, GAIN, MI and FFI, 2011).

In co-fortifying other micronutrients with iron, the quality of the iron fortificant is particularly important for the reason of bio-availability and not simply to be able to afford to add more micronutrients to the premix. Micronutrients should be selected according to population needs, costs and potential beneficial synergistic reactions the added micronutrients may have. It is therefore important to add the most beneficial iron compound at the right level since the objective is to prevent iron deficiency anaemia than to add B-vitamins such as B1, B3, B6. Focusing the current Nigerian cereal flour fortification standard (including wheat and maize flours) to iron, folate and vitamin B12 deficiencies which are the main micronutrients affecting anaemia and neural tube defects could therefore be more beneficial. Such premix in line with the new WHO recommendations would cost from 2 US$/MT (fortification with NaFeEDTA only) to less than 4 US$/MT (premix with NaFeEDTA, folic acid and vitamin B12) (Nutrition GAfI, 2012) and therefore could increase the capacity of the industry to bear the cost and fortify according to these new guidelines.

As shown previously, although vitamin A in cereal flour increases significantly the cost of the premix per MT, and questions have been asked on the need for addition of vitamin A to three different foods at such high levels, there is no question that flour is the most important staple food in Nigeria and its wide consumption makes it a good choice as a vehicle for fortification across all the zones of the country, which must be encouraged. Vegetable oils and sugar are also ideal vehicles, with fortified vegetable oils already a common programme imple-mented in many developing countries. The levels of the vitamin A in the processed foods, namely noodles, pan bread and biscuits, obtained in this study are significantly lower than the expected levels due to the individual sum of micronutrients in the vehicles theoretically calculated according to the prescribed standards obviously due to high processing losses, suggesting that there may be no risk of pre-disposition of consumers to hyper-vitaminosis as previously speculated.

Conclusion

This study has shown that current levels of added vitamin A and iron in cereal flours, or vitamin A only in vegetable oils and sugar, are unsatisfactory across all zones and far from being compliant with the prescribed National Industrial Standards after about ten years of implementation of the National Fortification Programme in Nigeria. It is suggested that this may very likely be due to under-addition of fortification premix at the industry level due to technological or other constraints or the use of inadequate quality premixes. It is also indicative of inadequate or ineffective monitoring of compliance by the regulators, possibly due to capacity or other constraints and the absence of self-regulation. Ultimately, the effect is that the additional intake of these micronutrients expected to be provided to the consumer is not realized and this potentially reduces the targeted reduction and/or prevention of vitamin and mineral deficiencies expected through the fortification programme. This therefore calls for a critical, urgent and holistic review of the current fortification strategy in Nigeria, especially in the areas of prescribed standards, training, monitoring and enforcement, consumer advocacy and public awareness.

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