Evaluation of the level of micronutrients in fortified foods in Alexandria, Egypt

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تقييم مستوى المغذيات الزهيدة المقدار بعد إغناء الأطعمة، في الإسكندرية، مصر

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الخلاصـة: يعد إغناء الطعام من الوسائل الزهيدة التكاليف والفعالة للتخلص من حالات عوز المغذيات الزهيدة المقدار في البلدان النامية. وهدفت هذه الدراسة في مصر إلى تقييم المستويات والتفاوتات في الإغناء بالحديد واليود والفيتامين أ في منتجات الطعام المستمدة من شركات مختلفة لصناعة الطعام. ووجد الباحثون أن جميع عينات الملح الميودَن تقريباً تحتوي على تـركيزات اليود في حدود المقاييس المصرية. أما محتوى البسكوت المغنى بالحديد، والذي يقدم للمدارس، ومحتوى المرغرين المغنى بفيتامين أ فلم يكن ضمن المقاييس المصرية. ومن الضروري مراقبة مستويات إغناء المنتجات الرئيسية على مستوى المصنع ومستوى التجزئة ومستوى الأسرة.

ABSTRACT Food fortification is an effective, low-cost way to eliminate dietary micronutrient deficiencies in developing countries. This study in Egypt aimed to evaluate the levels of and variations in fortification with iron, iodine and vitamin A in food products from different manufacturers. Almost all iodized salt samples contained iodine concentrations within Egyptian standards. The iron content of iron-fortified biscuits supplied to schools and of vitamin-A-fortified margarine, infant formula milk powder and infant cereal food were highly variable and many samples were not within Egyptian standards. Monitoring of fortification levels of key products is required at the factory, retail and household levels.

Évaluation du taux de micronutriments dans des aliments enrichis à Alexandrie (Égypte)

RÉSUMÉ L'enrichissement des aliments est un moyen efficace et peu coûteux d'éliminer les carences alimentaires en micronutriments dans les pays en développement. L'objectif de cette étude, réalisée en Égypte, était d'évaluer les taux et les variations d'enrichissement en fer, en iode et en vitamine A dans des produits alimentaires issus de différents fabricants. Quasiment tous les échantillons de sel iodé contenaient des concentrations en iode respectant les normes égyptiennes. La teneur en fer des biscuits enrichis en fer fournis aux écoles et la teneur en vitamine A de la margarine enrichie, du lait pour nourrissons et des produits céréaliers pour nourrissons variaient considérablement et de nombreux échantillons ne respectaient pas les normes égyptiennes. Un contrôle des taux d'enrichissement des produits essentiels est nécessaire au niveau de l'usine, du commerce de détail et du ménage.

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Introduction

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" [1]. Food fortification is recognized as being the most inexpensive and effective way to eliminate dietary micronutrient deficiencies. It is socially acceptable, does not change the characteristics of the food, requires no changes in food habits, has readily visible benefits and can legally be enforced for a nationwide action [2].

Deficiencies of iron, iodine and vitamin A are worldwide public health problems. At the World Summit for Children in 1990 goals were set for the year 2000 that included the virtual elimination of vitamin A and iodine deficiencies and the reduction of iron deficiency in women by one-third [3].

Interventions to combat micronutrient deficiencies in Egypt are targeted at different sectors of the population [4]. To combat anaemia in pregnancy, iron supplements are given to pregnant women via primary health care facilities. Schoolchildren are provided with biscuits fortified with iron and zinc. Nutrition education programmes aimed at increasing the consumption of dietary iron and enhancing its absorption are carried out. In addition, programmes for the eradication of parasitic infestations, and pilot studies for a national nutritional surveillance programme are under way. A flour fortification project has been discussed, including the fortification level, quality control and method of fortification [5]. Steps have been taken to start universal iodization of salt. Food fortification with vitamin A holds considerable potential as a tool to alleviate vitamin A deficiency.

This study in Alexandria city, Egypt, aimed to evaluate the levels of and variations in fortification of selected products: iron-fortified biscuits produced for school children; iodized table salt sold in local markets; and vitamin-A-fortified margarine, infant formula milk powder and infant cereal products sold locally.

Methods

Food samples

A total of 99 biscuit samples fortified with iron were analysed as follows: 54 packets of biscuits collected from 6 primary-school children feeding programmes in Alexandria city (36 samples produced during March and 18 produced during April); and 45 packets of biscuits collected from 5 different manufacturers (18 samples produced during March and 27 produced during April). Samples were collected in different months in order to detect **variations in the iron fortification levels in different production months.**

A total of 50 samples of iodized salt were selected randomly from the local markets of Alexandria city: 10 samples from batches of salt from 5 different manufacturers, both local and imported.

Samples of food products fortified with vitamin A were collected from the local markets of Alexandria city: 18 samples of margarine with different production dates (6 from each of 3 different manufacturers); 24 samples of infant formula milk powder (6 from each of 4 different manufacturers); and 12 samples of infant cereal food (6 from 2 different manufacturers).

Methods of analysis

The biscuits were analysed for iron using atomic absorption spectrophotometry by standard methods [6,7]. Egyptian standards for iron concentrations of fortified flour range from 37.5–62.5 ppm [standard no. 12018/2003].

Iodized salt was analysed for iodine using the titration method [8]. The Egyptian standards for the iodine content of iodized salt range from 30–70 ppm [standard No.2371-1/2005].

The vitamin A concentration of samples of fortified margarine, infant milk formula and baby cereal food was determined using spectrophotometric methods [9,10]. Percentage losses of vitamin A were calculated from the vitamin A content mentioned on the product label.

Statistical analysis

Statistical analysis was carried out using *SPSS*, version 11. The statistical tests used were as follow: cross-tabulations and percentages, arithmetic mean and standard deviation (SD), analysis of variance (ANOVA) and *t*-test. The levels of iron, iodine and vitamin A in samples were compared statistically across different batches and suppliers and with Egyptian national standards.

Results

Iron-fortified samples

Of the 45 iron fortified biscuit packets collected during March and April, 24 (53.3%) had iron concentrations lower than Egyptian standards (< 37.5 ppm), 21 (46.7%) were within the range of standards (37.5–62.5 ppm) and none were higher than the standards (> 62.5 ppm) (Table 1). Of the sample of 54 iron-fortified biscuits distributed to children in schools, 12 (22.2%) had an iron concentration lower than Egyptian standards, 27 (50.0%) were within standards and 15 (27.8%) were higher than standards.

The mean iron concentration of samples ranged from 9.24 (SD 0.76) ppm (company K) to 58.35 (SD 5.15) ppm (company D). The mean iron levels were significantly lower than the midpoint of the standard for samples from all the companies ($P < 0.01$) except for company K (insignificantly lower)

Table 1 Distribution of iron-fortified biscuit samples with iron levels lower than, within and higher than Egyptian standards collected from different companies and schools

Source/collection month	Iron concentration					
	< 37.5 ppm		37.5–62.5 ppm[a]		> 62.5 ppm	
	No.	%	No.	%	No.	%
Companies						
March (n = 18)	15	83.3	3	16.7	0	0.0
April (n = 27)	9	33.3	18	66.7	0	0.0
Total	24	53.3	21	46.7	0	0.0
School						
March (n = 36)	12	33.3	12	33.3	12	33.3
April (n = 18)	0	0.0	15	83.3	3	16.7
Total	12	22.2	27	50.0	15	27.8

[a]This is the Egyptian standards range.

and company D (significantly higher) in April (Table 2). There were substantial variations across samples at schools, ranging from 10.55 (SD 0.20) ppm (at school S) to 83.62 (SD 25.7) ppm (at school R). The mean iron levels in samples at all schools were significantly lower that the standard at 2 schools (P < 0.01) and significantly higher at 3 schools (P < 0.01).

There were also significant variations in mean iron concentrations

Table 2 Mean iron concentration of iron-fortified biscuit samples collected from different companies and schools during March and April

Source/collection month	Iron concentration (ppm)				*F*-value[a]	*t*-value[b]
	Package 1	Package 2	Package 3	Total		
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)		
Companies						
March						
Company D (n = 9)	17.74 (6.32)	35.50 (1.37)	37.49 (7.74)	30.30 (10.90)	18.60**	–5.79**
Company K (n = 9)	9.24 (0.76)	30.03 (17.60)	29.78 (4.48)	22.14 (11.90)	32.53**	–7.11**
Total (n = 18)	13.49 (6.01)	32.77 (3.87)	33.64 (5.76)	26.22 (11.40)		
April						
Company S (n = 9)	32.81 (4.07)	22.97 (2.58)	18.22 (4.03)	24.66 (7.44)	12.64*	–11.02**
Company D (n = 9)	53.99 (6.22)	58.35 (5.15)	58.33 (6.87)	56.70 (2.51)	0.5	3.51**
Company K (n = 9)	46.25 (7.02)	52.31 (6.25)	47.14 (3.67)	48.57 (3.28)	0.95	–0.74
Total (n = 27)	44.35 (10.72)	44.54 (18.93)	41.23 (16.66)	43.31 (1.93)	–	–3.969
Schools						
March						
School S (n = 9)	10.55 (0.20)	42.35 (4.93)	28.86 (5.80)	27.30 (16.00)	39.16**	–4.76**
School C (n = 9)	27.37 (1.58)	39.34 (7.36)	28.32 (3.880	31.67 (6.60)	5.56*	–7.70**
School R (n = 9)	57.52 (2.09)	69.66 (3.39)	83.62 (25.7)	70.27 (13.10)	2.28	3.53**
School M (n = 9)	64.51 (2.53)	70.50 (9.88)	58.54 (7.71)	64.52 (5.98)	1.96	5.30**
Total (n = 36)	39.99 (25.40)	55.46 (19.93)	48.44 (22.02)	48.44 (22.02)	–	–
April						
School D (n = 9)	48.96 (4.22)	47.91 (0.59)	55.21 (8.53)	50.59 (3.95)	1.54	0.35
School R (n = 9)	70.23 (1.58)	64.58 (7.10)	66.10 (3.48)	66.96 (2.92)	1.19	6.76**
Total (n = 18)	59.60 (15.04)	56.25 (11.78)	60.66 (7.70)	58.78 (11.58)	–	–1.59

[a]Comparing iron concentration among the 3 biscuit packages.
[b]Comparing iron concentrations with midpoint of Egyptian standards (50 ppm, range 37.5–62.5 ppm).
***P < 0.01*
SD = standard deviation.

Table 3 Distribution of iodized salt samples with iodine levels lower than, within and higher than Egyptian standards collected from different companies by production year

Company	Iodine concentration								
	Production date 2004			Production date 2005			Total		
	< 30 ppm	30–70 ppm[a]	> 70 ppm	< 30 ppm	30–70 ppm[a]	> 70 ppm	< 30 ppm	30–70 ppm[a]	> 70 ppm
	No.	No.	No.	No.	No.	No.	No.	No.	No.
Locally produced									
Company El (*n* = 10)	0	5	0	0	5	0	0	10	0
Company C (*n* = 10)	0	5	0	0	5	0	0	10	0
Company E (*n* = 10)	1	4	0	1	4	0	2	8	0
Total	1	14	0	1	14	0	2	28	0
Imported									
Company S (*n* = 10)	0	5	0	2	3	0	2	8	0
Company M (*n* = 10)	0	5	0	0	5	0	0	10	0
Total	0	10	0	2	8	0	2	18	0

[a]*Egyptian standards range: 30–70 ppm.*

across batches within each company. This variation was highly significant for companies D and K in March ($P < 0.01$) and company S in April ($P < 0.05$). Variations across batches were statistically significant at school S ($P < 0.01$) and school C ($P < 0.05$).

Iodine-fortified samples

Table 3 showed that all salt samples that were collected from companies EL, C and M had iodine concentration within Egyptian standards (30–70 ppm) during the year 2004 and 2005, whereas 2 out of 10 salt samples (from companies E and S) had below-standard iodine concentrations. No samples were higher than the standard (> 70 ppm).

The mean iodine concentration of samples was highest from company C, a local company [57.54 (SD 4.90) ppm], followed by company M (an imported product) [46.12 (SD 4.70) ppm] and company EL (local) [43.61 (SD 9.20 ppm]. The lowest mean iodine concentration was from company S salt (imported) [32.68 (SD 2.40) ppm] (Table 4). Only company C produced salt with an iodine concentration significantly higher than the average Egyptian standard 50 ppm ($P < 0.01$). The other companies had iodine concentrations lower than the standard, significantly so for companies E and S ($P < 0.01$). However, for all the companies there were no significant differences in the iodine levels comparing batches produced in 2004 and 2005, suggesting that the companies had uniform procedures for adding potassium iodate to salt.

Vitamin A- fortified samples

Margarine samples produced by the 3 companies studied contained low concentrations of vitamin A and varied greatly between the different brands, from a mean of 2.88 (SD 2.54) IU/10g

Table 4 Mean iodine concentration of iodized salt samples produced by different companies

Company	Iodine concentration (ppm)			t_1-value[a]	t-value[b]
	Production date 2004	Production date 2005	Total		
	Mean (SD)	Mean (SD)	Mean (SD)		
Locally produced					
Company EL (*n* = 10)	47.98 (10.81)	39.22 (5.23)	43.61 (9.2)	1.63	–2.18
Company C (*n* = 10)	58.32 (5.18)	57.28 (4.88)	57.54 (4.90)	0.08	4.8**
Company E (*n* = 10)	35.76 (3.64)	31.03 (8.45)	33.49 (6.60)	0.51	–7.86**
Imported					
Company S (*n* = 10)	34.22 (1.64)	31.33 (2.38)	32.68 (2.40)	1.16	–22.35**
Company M (*n* = 10)	48.61 (3.90)	43.62 (4.58)	46.12 (4.70)	1.12	1.59

[a]*Comparing iodine concentrations between samples produced during 2004 and 2005.*
[b]*Comparing iodine concentrations with midpoint of Egyptian standards (50 ppm, range 30–70 ppm).*
$^{**}P < 0.01$.
SD = standard deviation.

for company G to 60.99 (SD 27.38) IU/10g for company R. The highest percentage loss of vitamin A in margarine was in samples from company G (99.5%) followed by company E (68.2%) and the lowest in company R (39.0%). These levels were highly significantly lower than the concentrations mentioned on the label for companies G and E ($P < 0.01$) (Table 5).

Similarly, infant powder milk produced by 4 different companies contained vitamin A concentrations lower than the concentration on the label, although this difference was only significant for company L ($P < 0.05$) (Table 5). Mean measured concentrations ranged from 486.96 (SD 173.97) IU/10 g for company B1 to 1067.02 (SD 722.9) IU/10 g for company B2. The highest loss of vitamin A was in samples from company B1 (71.3%) and the lowest from company B2 (40.7%).

In the case of infant cereal food the mean measured concentrations of vitamin A were 446.41 (SD 271.34) IU/10 g from company R and 341.70 (SD 88.90) IU/10 g from company C, but considerably less than the labelled concentration (2500 and 1032 IU/10 g respectively) (Table 5). The percentage loss of vitamin A was 82.1% in the samples from company R and 66.9% from company C. This difference was significant for company R ($P < 0.01$).

Discussion

Food fortification, when imposed on existing food patterns, does not necessitate changes in the customary diet of the population and does not call for individual compliance. It can often be dovetailed into existing food production and distribution systems. For these reasons, fortification can be implemented and yield results quickly and be sustained over a long period of time. It can thus be the most cost-effective means of overcoming micronutrient malnutrition [11]. In developing countries, the focus of the international community has been on the 3 most prevalent deficiencies: vitamin A, iodine and iron [12].

Iron-fortified biscuits

The addition of iron to wheat flour is a common practice in many developed countries [12]. In a national programme for fortified complementary food it was associated with higher haemoglobin levels and lower prevalence of anaemia in children [11]. Various forms of iron are used in fortification [13], although no significant difference has been demonstrated between flour enriched with ferrous sulfate and that enriched with elemental iron [12]. The Egyptian standards for iron-fortified biscuits set a level of ferrous sulfate ranging from 37.5–62.5 ppm to be added to fortified flour.

In our study, among the iron-fortified biscuit samples collected from different manufacturers, 53.3% had iron concentrations lower than Egyptian standards (< 37.5 ppm). Of the iron-fortified biscuit samples distributed to children in schools, 22.2% were found to have iron concentrations lower than standards. A mean iron concentration as low as 10.55 ppm was detected in biscuit samples at 1 school, which was highly significantly lower than the mid-point of the Egyptian standards (50 ppm). Also a mean iron concentration as high as 83.62 ppm was detected in some biscuit samples of another school

Table 5 Percentage loss of vitamin A in samples of fortified margarine, infant powder milk and infant cereal food produced by different companies

Product/ company	Production dates (range)	Storage time before analysis (range in months)	Vitamin A concentration (IU/10 g)			*t*-value[a]
			Actual Mean (SD)	Product label	% loss	
Margarine						
Company R ($n = 6$)	11/2005–02/2006	3–18	60.99 (27.38)	100.0	39.1	–2.46
Company G ($n = 6$)	02/2005–07/2005	13–15	2.88 (2.54)	570.0	99.5	–129**
Company E ($n = 6$)	09/2005–12/2005	5–8	9.55 (2.29)	30.0	68.2	–21.77**
Infant formula milk						
Company B1 ($n = 6$)	12/2004–8/2005	9–17	486.96 (173.97)	1698.3	71.3	0.23
Company B2 ($n = 6$)	09/2004–3/2005	16–20	1067.02 (722.9)	1800.0	40.7	1.43
Company S ($n = 6$)	03/2005	17	687.94 (371.0)	1400.0	50.9	–2.71
Company L ($n = 6$)	03/2005–04/2005	11–17	914.27 (243.5)	1800.0	49.2	–6.29*
Infant cereal food						
Company R ($n = 6$)	05/2005–10/2005	7–12	446.41 (271.34)	2500.0	82.1	–13.11**
Company C ($n = 6$)	03/2005–10/2005	7–12	341.70 (88.90)	1032.3	66.9	0.62

[a]*Comparing vitamin A in samples with vitamin A concentration on label.*
$^*P < 0.05$; $^{**}P < 0.01$.
SD = standard deviation.

and this was significantly higher than the standards.

Minerals are more resistant to manufacturing processes than vitamins. However, they do undergo changes when exposed to heat, air or light. Minerals such as iron are affected by moisture and may react with other food components such as proteins and carbohydrate. Iron and other minerals may be also lost through leaching into cooking and processing water [13]. When added to bakery flour, levels higher than 40 ppm or storage for more than 3 months under high temperature and humidity have been found to cause rancidity and taste deterioration [13].

Large variations in iron content between different batches of biscuits were also found in our study, which were significant for 3 of the 4 companies and at 2 of the 6 schools. This suggests that the amounts of ferrous sulfate added to flour were not consistent in all the producing companies. Ensuring the adequacy and quality of fortified food products from production to consumption is a critical component of any food fortification programme; it should be a primary concern of the food industry to validate the consistency of the manufacturing process to achieve a uniformly fortified product for distribution that has all the intended characteristics and qualities. The availability of trained staff to carry out the procedures is of great importance for a successful outcome [14].

Iodized salts

The most successful global fortification experience is the fortification of salt with iodine. A number of countries have successfully iodized their salt supplies, thus reducing the rates of goitre and cretinism, preventing mental retardation and subclinical iodine deficiency disorders, and contributing to improving national productivity [15]. Once established in a country, salt iodization is a permanent and long-term solution to the problem of iodine deficiency. Toxicity issues are negligible and cost considerations fairly small, amounting to only 1 to 3 US cents per person per year [11].

Potassium iodate is preferred to potassium iodide for salt iodization as it is resistant to oxidation and does not require the addition of stabilizers [14]. In Egypt salt is fortified by adding 30–70 ppm potassium iodate. In the present study salt samples from 3 of the 5 companies studied (2 local, 1 imported) had iodine concentrations within Egyptian standards (30–70 ppm). In 2 other companies (1 local, 1 imported) salts batches had iodine concentrations < 30 ppm. The mean iodine concentration was highest in a local company (57.5 ppm), and lowest in an imported brand (32.7 ppm). Only 1 (local) company produced salt with an average iodine concentration significantly higher than the standard, at 57.5 ppm.

The stability of iodine in salt depends on the water content, acidity and purity of the salt to which it is added. In order to reduce iodine losses during storage, the iodized salt must be as pure and as dry as possible, and it must be appropriately packaged [16].

In our study no significant variations were detected between different batches of salt produced during 2004 and 2005, suggesting that all the companies were consistent in the amounts of potassium iodate used for fortification of salt.

Although considerable progress has been made in control programmes of salt iodization in several countries including Egypt, producer compliance, quality assurance, logistic problems and supply bottlenecks remain. The challenge is to systematically identify and tackle these constraints through effective advocacy, social communications, monitoring of salt iodine levels, regulation and enforcement [11].

Vitamin A-fortified products

Food fortification with vitamin A holds considerable potential as a tool to alleviate vitamin A deficiency by bridging the gap between dietary intake of vitamin A and requirements [14]. Pure vitamin A and carotenoid structures are fairly stable when heated to a modest temperature in an inert atmosphere and in the dark, but are unstable in the presence of oxygen or air or when exposed to ultraviolet light. The food fortification industry has developed vitamin A and carotenoid structures with addition of antioxidants as stabilizing agents [17].

In the present study margarine samples produced by the 3 different companies contained low concentrations of vitamin A, significantly lower than the concentrations on the label in margarine from 2 of the 3 companies. The loss of vitamin A ranged from 39.0% to 99.3%. These percentages were extremely high and were not related to the time of storage before analysis. For example, margarine samples from 1 company stored for 3 months at room temperature had a percentage loss of 32.4% and 69.1%, which was higher than those stored for 18 months (15.6%). These results contradict data showing that storage of vitamin-A-fortified margarine for 6 months at 20–25 °C results in only minimal losses [18]. Losses occurring during heating or overstorage would be due to oxidation of the oily vitamins, a process that would cause rancidity of the fats at the same time [14].

Infant powder milk produced by the 4 different companies contained vitamin A concentrations lower than the concentration on the label, although the differences were not significant for any of the companies except for one. Vitamin A concentrations ranged from 486.96 IU/10g to 1067.02 IU/10g across products from different companies. Compared with the labelling, vitamin A was found to be lost in infant milk powder samples at percentages ranging from 49.2%–11.3%. These percentages were high but were parallel to the time of storage before analysis, especially for 1 company. This was not the case, however, for samples from the other 3 companies.

These results may be interpreted by the improper packaging and handling of the products, which in Egypt may be transported over long distances under hot and humid conditions leading to micronutrient losses [19]. Micronutrient losses can be reduced by adding appropriate plastic coating to packages. Because of high costs and the lack of availability of packaging material in developing countries, packaging assumes great importance and should be a major factor to consider at the beginning of a fortification programme [13].

Similarly, infant baby food produced by both of the 2 companies investigated had vitamin A concentrations significantly lower than the label. Again the percentage loss of vitamin A in baby food samples was very high in both cases (82.1% and 66.9%) and did not seem to be related to the length of storage. Studies showed that losses of vitamin A from fortified cereals can be as high as 40% depending on ambient conditions and storage times [20–22]. Other studies mentioned that between 30% and 50% of vitamin A that is added to the blended cereals is lost in shipping and storage [23–25]. Packaging may again have an effect. This can be overcome by adding the appropriate plastic coating and/or an appropriate overage of the most sensitive micronutrients, such as vitamin A.

For all these vitamin-A-fortified products, the amount of vitamin A mentioned on the label may be not the one added to the products. Thus another interpretation of the results may be inadequate fortification levels during manufacture, especially in the case of powdered milk, where the fortification can be been achieved in different ways (by the addition of dry vitamin preparations to the milk powder or by vitamin addition to the liquid milk just prior to spray drying).

It is known that vitamin A breaks down at a predicted percentage ranging from 10% to 15% after 6 months of storage at 20 °C and 75% relative humidity [13]. Moreover, the choice of the food-processing operation greatly affects vitamin losses; roller drying, for example, causes vitamin A losses of 26.2% (process loss) and 39.2% (at 6 months of storage) and 60.6% (at 12 months of storage). Proper food-processing operations should be used to minimize the deterioration of vitamins caused by oxidation during drying. Nutrients may be added after drying. This process is relatively simple and efficient, but requires extra mixing equipment which may not be available in developing countries [18].

To compensate for micronutrient losses an appropriate overage of the most sensitive micronutrients can be added [12]. The overage will vary according to the inherent stability of the nutrients, the conditions under which the food is prepared and packaged, and the anticipated shelf life of the product. Thus, the more labile or unstable nutrients, such as vitamin A, generally require high overages. An overage of 25% is needed for milk-based fortified drink powder with a shelf life of 12 months. This means that if the declared amount of vitamin A is, for example, 20 mg/g of product, then the input level or the amount of nutrient in the formulation should be 25 mg/g of product [13].

Food fortification aims to provide meaningful levels of the nutrient, usually 30% to 50% of the daily adult requirements, at normal levels of consumption of the food. The levels also need to take into account variations in food consumption so that the safety of those at the higher and of the scale and impact on those at the lower end are ensured. They should also consider prorated intakes by young children to ensure efficacious and safe dosages [11].

Recommendations

Based on the results of our study we recommend monitoring of fortification levels of key products at the factory, retail and household levels to provide more rapid feedback about the adequacy of fortificant levels. It is also important to ensure that food is packaged and stored appropriately as these influence micronutrient losses. An overage of fortificants (especially of the most sensitive micronutrients, such as vitamin A) may be required to compensate for losses during processing, distribution and storage.

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