Implementing large-scale food fortification in Ghana: Lessons learned

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Abstract

Background. *Food fortification began in Ghana in 1996 when legislation was passed to enforce the iodization of salt. This paper describes the development of the Ghanaian fortification program and identifies lessons learned in implementing fortification initiatives (universal salt iodization, fortification of vegetable oil and wheat flour) from 1996 to date.*

Objective. *This paper identifies achievements, challenges, and lessons learned in implementing large scale food fortification in Ghana.*

Methodology. *Primary data was collected through interviews with key members of the National Food Fortification Alliance (NFFA), implementation staff of the Food Fortification Project, and staff of GAIN. Secondary data was collected through desk review of documentation from the project offices of the National Food Fortification Project and the National Secretariat for the Implementation of the National Salt Iodization in Ghana.*

Results. *Reduction of the prevalence of goiter has been observed, and coverage of households with adequately iodized salt increased between 1996 and 2006. Two models were designed to increase production of adequately iodized salt: one to procure and distribute potassium iodate (KIO_3) locally, and the second, the salt bank cooperative (SBC) model, specifically designed for small-scale artisanal salt farmers. This resulted in the establishment of a centralized potassium iodate procurement and distribution system, tailored to local needs and ensuring competitive and stable prices. The SBC model allowed for nearly 157 MT of adequately iodized salt to be produced in 2011 in a region where adequately iodized salt was initially not available. For vegetable oil fortification, implementing quantitative analysis methods for accurate control of added fortificant proved challenging but was overcome with the use of a rapid test device, confirming that 95% of vegetable oil is adequately fortified in Ghana. However, appropriate compliance with national standards on wheat flour continues to pose challenges due to adverse sensory effects, which have led producers to reduce the dosage of premix in wheat flour.*

Conclusions. *Challenges to access to premix experienced by small producers can be overcome with a central procurement model in which the distributor leverages the overall volume by tendering for a consolidated order. The SBC model has the potential to be expanded and to considerably increase the coverage of the population consuming iodized salt in Ghana. Successful implementation of the cost-effective iCheck CHROMA rapid test device should be replicated in other countries where quality control of fortified vegetable oil is a challenge, and extended to additional food vehicles, such as wheat flour and salt. Only a reduced impact on iron deficiency in Ghana can be expected, given the low level of fortificant added to the wheat flour. An integrated approach, with complementary programs including additional iron-fortified food vehicles, should be explored to maximize health impact.*

Key words: Food fortification, Ghana, salt, vegetable oil, wheat flour

Background

Among the goals announced at the 1990 World Summit for Children was the elimination or significant reduction of iodine, vitamin A, and iron deficiencies [1]. In Ghana, data from the 1993 Demographic and Health Survey [2] and the 1995 National Vitamin A and

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Anemia Prevalence Survey* indicated widespread deficiencies, with more than 70% of school-aged children and almost 60% of women of reproductive age with anemia. The data also showed that 75.8% of the population had vitamin A deficiency (serum retinol < 0.7 μmol/L) and that severe iodine deficiency affected one-third of the Ghanaian districts [3, 4]. Based on these data, large-scale food fortification was identified by the Ghanaian government as an effective national strategy [5–11] to improve the nutritional status of the population, in addition to other public health initiatives, such as promotion of exclusive breastfeeding for the first 6 months, vitamin A supplementation for children under 5 years of age, and improved foods for infants and young children.

Implementation of the food fortification strategy began in Ghana in 1996, when legislation was passed to enforce the iodization of salt [12]. Following World Health Organization (WHO) recommendations [13], the legislation mandated the fortification of salt produced for human and animal consumption with potassium iodate (KIO_3) to alleviate conditions associated with iodine deficiency. Moreover, because Ghana is a major salt producer and an exporter to many West African countries [14], Ghana's Universal Salt Iodization (USI) program was anticipated to improve the health of people living in neighboring countries.

One of the first critical actions taken following the adoption of legislation for salt iodization was the establishment of a National Salt Iodization Committee (NSIC) in 1996 under the chairmanship of the Ministry of Health. The NSIC facilitated salt iodization to start in Ghana by successfully bringing together various stakeholders from the public, private, and nongovernmental sectors. In addition to the selection of salt for iodization, additional vehicles for cost-effective food fortification interventions [5] were selected based on large-scale commercial processing and the likelihood that the product would be consumed by the majority of the population. The National Food Fortification Alliance (NFFA), constituted in 2003, designed the Food Fortification Project to fortify wheat flour and commercial vegetable oil to address the high levels of anemia and vitamin A deficiency in the country.

Even though many locally produced and widely consumed staples were considered, many of these staples were milled by thousands of small millers scattered throughout the country. In contrast, wheat flour was processed in four main factories that accounted for over 90% of total flour production in the country. In addition, a survey carried out by the University of Ghana in 2004 [15] found that products made from wheat flour were consumed by 95% of households nationally. This survey among 800 households also found that about 50% of children under 5 years of age and 25% of children 6 to 11 months of age consumed bread regularly. It also found that rural children consumed about the same amount of bread as urban children owing to a large network of small rural bakeries. This was also confirmed by the Ghana Living Standards Survey [16], which found that rural purchases of flour and bread were 85% and about 75%, respectively, of the national average purchases of these items. It was projected that flour would reach up to 95% of the population, including the poor, with an average consumption of 56 g/day of flour products.

The choice of vegetable oil was based on the fact that it is consumed by 98% of households and its consumption is widespread across all income and age groups [15]. Vegetable oil is consumed on a daily basis in Ghana, as it is a key ingredient in sauces and stews that accompany starchy staples, such as cassava, maize, and plantain. One domestic vegetable oil producer accounts for 40% of the Ghanaian market, while the remaining 60% of oil sold is imported by a small number of companies.

This paper documents the implementation of the Ghanaian large-scale fortification strategy from 1996 to 2012. By discussing the experiences of stakeholders in fortifying salt, wheat flour, and vegetable oil, this paper identifies achievements, challenges, and lessons learned in implementing fortification initiatives.

Results

To date, food fortification standards have been developed for salt, wheat flour, and vegetable oil in Ghana. Standards (GS152) relating to the fortification of salt address issues of production and packaging of salt. The standards in 1996 specified that 100 ppm of potassium iodate be added during production in order to maintain a concentration of 50 ppm at the point of sale. In 2006 these figures were revised by the NSIC to 50 ppm during production to achieve a minimum of 15 ppm at the retail and household levels. Ghana Standards (GS 809:2006, GS810:2006, GS 811:2006, GS812:2006, and GS 813:2006) were developed in 2006 to regulate the premix composition of the fortified vehicles as well as the levels of selected vitamins and minerals for fortified strong wheat flour, soft wheat flour, and vegetable oil (**tables 1** and **2**). The minimum level of fortification was determined by setting a target of delivering at least 20% of the Estimated Average Requirement (EAR) for vitamin A and folate and 20% of the Recommended Nutrient Intake (RNI) for iron, based on the average consumption of the respective foods. These levels were expected to have no impact on the organoleptic properties of the products and to account for variation and retention during processing and utilization.

* Quarshie K, Amoaful E. Proceedings of the workshop on dissemination of findings of vitamin A and anaemia prevalence surveys. Accra: 1998.

TABLE 1. Ghana standard for wheat flour fortification

Micronutrient	Fortificant	Level of Quantity (mg/kg)
Vitamin A	Palmitate CWS 250	2.0
Folic acid	Folic acid	2.08
Vitamin B_{12}	Vitamin B_{12} 0.1% WS	0.01
Thiamine	Thiamine mononitrate	8.4
Riboflavin	Riboflavin	4.5
Niacin	Nicotinamide	59.0
Iron	Ferrous fumarate	58.5
Zinc	Zinc oxide	28.3

While standards for fortified flour and vegetable oil were being developed, the Government of Ghana initiated a process of reviewing its laws and policies on public health to have all legal instruments on health harmonized in one act of parliament, the Public Health Act. In view of this, parliament could not easily isolate and pass a single legislative instrument to make fortification mandatory. Since a legislative instrument proved to be a complex political undertaking, the Food and Drugs Board (FDB) opted for a ministerial directive to enhance the enforcement of the standards on fortification and elevate them to technical regulations. This ministerial directive enabled the Ghana Standards Board (GBS) to designate the fortification standards as a Technical Regulation to protect health. GSB notified the World Trade Organization (WTO), and upon review by WTO member countries and a finding of "no-objection," a Technical Regulation was issued and became an enforceable technical regulation on November 6, 2009 [13].

Since the establishment of the standards, salt iodization in Ghana has been ongoing for well over 16 years, with the target of covering at least 90% of the population. Although the percentage of households with adequately iodized salt has increased from only 0.7% in 1996 to 32% in 2006 [3, 17], a survey carried out in 2007 [18] showed that the prevalence of goiter dropped by 20% at two sentinel sites (Bongo and Jirapa districts) since the implementation of salt iodization legislation in 1996. Two major factors were identified as the causes for the low coverage of iodized salt in Ghana. The main challenge was that small salt producers were experiencing difficulties in accessing reputable international suppliers for their individual quantities and minimum order quantities, and pack sizes were not suitable for the production requirements, making it difficult and very expensive to source their potassium iodate. The President's Special Initiative on Salt, a partnership between industry and a division of the Ministry of Trade and Agriculture, was established in 2007 to organize the salt business. To address the procurement challenge, a supply and distribution system was set up in 2009 by the Global Alliance for Improved Nutrition (GAIN) Premix Facility with support from the President's

TABLE 2. Ghana standard for vegetable oil fortification

Micronutrient	Fortificant	Level of fortificant (mg/kg)
Vitamin A	Retinol palmitate	10.0

Special Initiative on Salt, and NSIC. An initial stock of 5 MT of potassium iodate was supplied to a private company, Environmental Processing Associates Ltd. (EPA) by the GAIN Premix Facility under a consignment model whereby EPA acts as the local distributor for KIO_3 in Ghana. EPA imports commercial quantities of KIO_3 to Ghana (25 kg drums), re-packages it, then re-sells and distributes this KIO_3 in smaller packages to small-scale and other salt producers at cost plus a small management fee. With this local distribution hub mechanism, potassium iodate was supplied through a revolving mechanism to EPA, which then resupplied the local market. This initiative enabled the establishment of a tailored and sustainable system of supply for potassium iodate.

Another major reason identified by the government for lack of access to iodized salt was the inability of the numerous small-scale salt producers in Ghana to adequately iodize their production of salt. In order to respond to this challenge, GAIN established a cooperative model whereby salt producers in a locality sell raw salt to a centralized salt bank, which then iodizes, quality tests, packages, and sells the salt in the market. The establishment of a salt bank cooperative (SBC) for small-scale producers was identified as a key vehicle to help reach the desired national target. By regrouping small-scale salt producers, the SBC model facilitates a more efficient method for producing, iodizing, marketing, and selling iodized salt in different packaging sizes. In cooperation with the Ghana Health Service, FDB, the Ministry of Trade and Industry, and salt producers, GAIN provided the up-front investment and training to establish a SBC in a pilot region, Nyanyano, in 2010. After 1 year of activity, in a region where almost no adequately iodized salt was available, the establishment of the SBC allowed nearly 157 MT of adequately iodized salt to be produced in 2011.

While efforts were being made to strengthen the USI program, fortification of wheat flour and vegetable oil started in 2007. Internal quality control procedures, external inspections, and regular collection of wheat flour and vegetable oil samples were implemented by the FDB. These systems were rapidly put in place, but the analysis of the collected samples presented difficulties, particularly for the detection of retinyl palmitate in fortified vegetable oil.

Although the atomic absorption spectrophotometry (AAS) equipment used by the FDB laboratory allowed adequate iron levels in wheat flour samples to be ensured, the high-performance liquid chromatography (HPLC) device could not be successfully implemented to test retinyl palmitate in vegetable oils. The test results showed the presence of vitamin A, but no samples were found to be adequately fortified according to the analyses in 2008 and 2009. However, audit reports cross-checking industry reports of premix quantities used and production outputs indicated that the vegetable oil refineries were fortifying at the required level. Audit reports also indicated that the oil refineries had an adequate quality assurance system, and their records confirmed they were fortifying to specification. A few samples were sent to a third party laboratory for reference analysis; the results indicated that the samples were adequately fortified with vitamin A. The FDB thus concluded that the HPLC methodology was too complex and prone to inappropriate handling by the FDB laboratory. Additionally, although a spot test for iron in wheat flour was available for port of entry enforcement, no such rapid assessment method was available at ports of entry for imported vegetable oil. The problems associated with the inaccuracies in conducting HPLC analyses made it necessary to send samples to nongovernmental laboratories for analyses. This led to delays of several days in obtaining results and created important delays in granting clearance for these oils.

In 2010 a portable rapid test device was identified as an alternative solution for testing retinyl palmitate in oils. This device, the iCheck CHROMA rapid test device, allows almost instant testing of vitamin A levels [19] and requires only very minimal training. Use of this portable device for testing retinyl palmitate at the port of entry allowed officials to test imported fortified vegetable oil in a much more efficient way. Quantitative results could be obtained almost instantly, thus facilitating regulatory decisions. It also improved the credibility of the Ghana FDB and customs with industry partners by avoiding import delays. Since the introduction of the portable testing device in 2010, port of entry control of vegetable oil has significantly improved. The percentage of oil that was tested as fortified increased from 42% in 2009 to 100% in 2011. Between 2010 and 2011, the percentage of adequately fortified vegetable oil increased from 69% to 95% (**table 3**).

This significant improvement was confirmed by the results of a nationally representative market survey conducted by the FDB in 2011. The market sites were selected to be representative of the urban–rural distribution of Ghana. The survey focused on major markets that feed into smaller markets within a region as well as markets in border towns. At each site, FDB officers purchased one sample each of all brands of vegetable oil found in each selected market. The samples were then forwarded to Accra for analysis with the iCheck CHROMA device. The survey results confirmed that 95% of the vegetable oil was adequately fortified. From a critical situation in which none of the samples could be appropriately tested by HPLC in 2009, the introduction of the iCheck CHROMA device in 2011 concluded that almost all of the vegetable oil in Ghana was adequately fortified.

Although the enforcement of vegetable oil fortification has been improved, compliance with wheat flour fortification standards continues to pose challenges. The 2011 FDB survey showed that only 23% of wheat flour samples were adequately fortified (45 ppm of iron). Fortification of wheat flour started in 2007 with the four active wheat flour millers. However, there was a sharp drop in the percentage of adequately fortified flour after the first year of production (**table 4**). Two principal wheat flour producers, accounting for 90% of the total local production in Ghana, were responsible for the majority of this important decrease, as they decided to fortify considerably below the Ghana standards.

This decision to lower the premix dosage was made by the first miller after bakers reported flour quality issues during storage. Furthermore, the bakers complained of poor rising of dough, resulting in a smaller loaf when fortified wheat flour was used. These quality defects were attributed by the flour miller to the fortificant, specifically to the iron compound. Subsequently, the miller reduced the premix dosage below the specified levels prescribed in the Ghana standards, incorporating the premix at a rate of 100 g/MT of flour instead of 350 g/MT of flour. The company reported that the fortification process was hindering the wheat flour production process, causing the wheat flour to be unacceptable to the customer and creating financial and market share losses for the company. Subsequently, the second main wheat flour miller expressed concerns about the lack of a level playing field, since its competitor was reducing its production costs by reducing the amount of fortificant added per metric ton of flour, and reduced its rate of addition to 180 g/MT. Consequently,

TABLE 3. Results of testing of vegetable oil samples by the Food and Drugs Board

Year	No. of samples tested	Fortified		Adequately fortified	
		No.	%	No.	%
2011	164	164	100	156	95
2010	204	201	99	141	69
2009	33	14	42	—	—
2008	309	131	42	—	—

TABLE 4. Results of testing of wheat flour samples by the Food and Drugs Board

Year	No. of samples tested	Fortified		Adequately fortified	
		No.	%	No.	%
2011	85	74	87	11	13
2010	193	103	53	90	47
2009	274	206	75	68	25
2008	92	92	100	92	100

to date, most flour on the Ghanaian market is fortified below the required standard. This is reflected in FDB monitoring reports, which showed that 13% of market samples analyzed complied with fortification requirements (**table 4**).

Although sensory evaluations were conducted originally to ensure that the organoleptic properties of bread were not altered by the fortificant at levels required by the Ghanaian standards, additional sensory tests were conducted to determine whether the bakers' claims were founded and this level of the iron compound used as a fortificant negatively affected the bread produced. One of the tests conducted used different premixes with selected iron compounds at the required levels (ferrous sulfate, ferrous fumarate, and sodium iron ethylenediaminetetraacetate [NaFeEDTA]) as well as the ferrous fumarate added at a lower incorporation rate. The doughs produced with the different types of fortified flours were assessed and rated based on the external (length, symmetry of form, top crust, break, shred, bloom) and internal (grain uniformity, texture, and crumb color) loaf characteristics as well as a sensory analysis. A 6-hour fermentation time was used to reflect traditional Ghanaian baking conditions. The test results did not show that the iron compound was having a negative effect on the organoleptic properties of the bread, nor that fortified flour was causing the bread to be unacceptable to customers, since no significant differences in crumb color, taste, or bread volume were found.

However, FDB AAS results over the years show a great variability in the mean iron concentration (ppm) in the wheat flour samples from the two companies (**table 5**), suggesting that wheat flour producers in Ghana have difficulty in producing a homogeneously fortified product. Although the proportion of samples tested with no iron (< 10 ppm iron) increased from 5% in 2009 to 43% in 2010, the proportion with iron content above 90 ppm also increased from 10% to 43%*. More than 80% of all samples tested either had almost no iron content or had iron content more than 50% higher than the standard. This suggests significant issues with consistent addition of premix and homogeneity of flour, particularly when the premix dosage is reduced at a lower addition rate. With such a significant share of flour fortified with very high iron content, it is possible that the inadvertently high levels of added premix may be a source of the product quality issues reported by bakers.

TABLE 5. Percentage of wheat flour samples tested by the Food and Drugs Board showing no fortification (< 10 ppm iron) or very high levels of fortification (> 90 ppm iron)

Iron level (ppm)	2008	2009	2010
< 10	0	5	43
> 90	17	10	43

Based on an estimated per capita consumption of flour of approximately 60 g/day in Ghana, the amount of additional iron provided is approximately 0.8 mg/day when the reduced dosage of 100 g of premix per ton of flour is used, compared with 2.7 mg/day when the premix is incorporated at 350 g per ton of flour. This current additional iron amount of 0.8 mg/day is considerably below the 7.1 mg/day minimum amount reported to be efficacious in the studies reviewed by Hurrell et al. [20]. From a public health perspective, the lower premix dosage reduces the potential impact of the wheat flour fortification project, at the same time decreasing the levels of the other micronutrients contained in the premix.

Finally, in addition to setting up the quality control systems, formative research was conducted to inform the development of the social marketing and communication strategy. The research indicated that both consumers and industry were in favor of the project and did not express any potential barrier to its success. Comments from industry, however, suggested that the government will have to educate the general population on the health benefits of fortified products. The initial social marketing and communication plan was implemented by the Ministry of Health, but midterm evaluation reported that only 23% of the population had heard about the project and only 12.1% could identify the fortification logo. This result was explained by the fact that most of the mass media campaigns were done through radio and the use of health workers, which was not effective in promoting a visual logo. Contrary to the Ghanaian government's expectations, it also appeared that manufacturers have not attempted to leverage the national social marketing efforts with parallel marketing investments to promote their products as fortified

* Bagriansky J. End-of-project evaluation report. Ghana Wheat Flour and Vegetable Oil Fortification Project. 2012.

or to relay publicity around the fortification logo. This is due to the fact that vegetable oil and wheat flour are essential commodities and the market is not saturated with products. Subsequently, a revised strategy was implemented by a private communication agency that placed more focus on market activation and television advertisement to provide more exposure to the logo. Through the Ministry of Women and Children, school activation programs were also developed to raise awareness of the benefits of fortified food products.

In spite of the low level of awareness created by the social marketing and communication campaign, as recorded by the midterm survey, the fortification logo has attracted the attention of other food producers. Some producers of products such as biscuits have approached the FDB about the possibility of using the logo on voluntarily fortified food items. Although the use of the logo is restricted to fortified wheat flour and fortified vegetable oil, a spin-off consequence of the social marketing campaign is a certain interest in voluntary fortification and an opportunity to engage in targeted fortification.

Discussion

By making salt iodization mandatory in 1996, Ghana was at the forefront of establishing food fortification. This effort to fight iodine deficiency was complemented later on with an important initiative to alleviate other micronutrient deficiencies and reduce the nutrient gap in the Ghanaian diet by fortifying wheat flour and vegetable oil.

NSIC and NFFA were successfully established and have been successfully implementing large-scale food fortification. Public–private partnerships were also an important foundation for driving the development agenda forward and a critical step in initiating the production of fortified foods. Enforcement of the fortification standards was supported by an interim ministerial directive until the legislative instrument was put in place.

However, large-scale food fortification is complex and requires multiple components to be enforced in order to achieve the anticipated impact. Several key factors are important for this, including availability and distribution of the premix, industry compliance, having appropriate standards and regulatory environment, and raising consumer demand and awareness of fortified products, as well as technical assistance to create an enabling environment and ensure enforcement and sustainability of the initiatives.

The implementation of two innovative program models has helped Ghana to respond to the challenges faced in expanding salt iodization. An ongoing revolving mechanism is now established that ensures a continuous supply of potassium iodate at a stable and competitive cost, which is crucial for the program's sustainability. The impact on national coverage of salt iodization has to be determined. In 2011, as a result of restructuring at the Ghana Ministry of Trade, the responsibility for managing the supply model was transitioned to a local company, Environmental and Processing Associates Limited. Although the supply and distribution system of potassium iodate is sustainable and has successfully been transitioned to a local company, the SBC model is newer; financial viability and sustainability of the SBC initiative is vital to ensure its replicability. Ensuring adequate quality assurance and control processes at the production level remains a challenge. This will include procurement of appropriate equipment by the SBC to carry out its own quality assurance and control procedures and ongoing technical support to ensure it is used appropriately. Initial baseline survey data indicate that the potential in terms of protection against iodine-deficiency disorders is considerable: at full scale, the overall yearly production for the SBC in Nyanyano could be in the region of 10,000 MT of salt. This amount of iodized salt could protect more than 2 million people against iodine-deficiency disorders.

Introduction of the iCheck CHROMA rapid test device in Ghana has proved an efficient and user-friendly way to improve compliance at the borders, facilitate regulatory decisions, avoid trading delays at ports of entries, and strengthen external quality control. This cost-effective technology not only significantly enhances the speed and availability of quality control data but also overcomes major training and capacity challenges that are often experienced at the country level when HPLC is used. As compared in Côte d'Ivoire with an HPLC method, the iCheck CHROMA rapid test method has yielded positive results, confirming that it is very useful in low-resource settings [19]. Furthermore, lessons learned in Ghana can be easily applied in other countries where vegetable oil is being fortified and where quality control is a challenge. Finally, based on the successful experience with vegetable oil, the scope of use of such rapid test kits could be extended to additional food vehicles, such as wheat flour or salt.

The Ghana standards were prepared and established in an effort to prevent micronutrient deficiencies in the country. At the time, only a few studies had looked at the bioavailability and adverse sensory effects of the iron compound in developing countries [15, 21–23]. However between 2004 and 2007, the number of countries with mandatory wheat flour fortification programs rose from 33 to 54 [24], providing more opportunities to learn and build evidence from the different fortification standards and practices that vary from country to country. It is well established that the choice of the fortificant compound, in this case the iron compound, should be a reasonable compromise in terms of cost, bioavailability, and associated sensory changes [25]. Moreover, standards need updating in many countries to ensure that wheat flour is fortified with adequate levels of the recommended iron compounds.

With a consumption level of wheat flour below 60 g/day, the current Ghanaian fortification standards (45 ppm of ferrous fumarate) do not meet the WHO recommendations (60 ppm of ferrous fumarate). However, given the resistance of industry to incorporating the currently prescribed amounts of premix and the fear of organoleptic changes, an increase to 60 ppm is likely not to be well accepted. Electrolytic iron is not recommended for flour intakes of less than 150 g/day. Because of its low bioavailability, very high levels of electrolytic iron would be needed, which could negatively affect the sensory properties of fortified flour [23]. NaFeEDTA at 40 ppm is one of the options to be considered. With a much higher bioavailability and better iron absorption, NaFeEDTA allows for a lower level for fortification and potentially less likelihood of sensory changes [2]. In view of the fact that bread in Ghana has high levels of butter, ranging from 5% to 10%, and the potential of interaction with iron, it might be worth investigating the effect of different forms of iron compounds, which, if acceptable, could increase the compliance level. It is to be noted that at its current estimated rate of consumption in Ghana, wheat flour would provide only 2.4 mg iron/day, even if NaFeEDTA was the selected fortificant at 40 ppm. This is well below the 3.5 mg/day minimum reported to be efficacious in the studies reviewed by Hurrell et al. [20, 26]. An integrated approach, with complementary programs including additional iron-fortified food vehicles, should be explored to increase the amount of iron in the Ghanaian diet.

Conclusions

Large-scale food fortification has been successfully integrated overall within the Government of Ghana's national programs as a comprehensive effort to address micronutrient deficiencies in the country. The Ghana experience shows that national fortification programs take several years to develop and that challenges to program implementation can be addressed through new technologies and programming models. Key lessons can be drawn: the two innovative models designed to increase production of adequately iodized salt, a sustainable potassium iodate procurement system and the SBC model, were established. The challenges to accessing premix experienced by small producers have proved manageable with the central procurement model, whereby the distributor leverages the overall volume by tendering for a consolidated order. The SBC model, which is newer, has the potential to expand and to increase the coverage of the population consuming iodized salt in Ghana. Furthermore, regular and accurate control of the content of added fortificant is a critical indicator for program success and impact, at the level of both supply and coverage of fortified foods. The implementation of quantitative analysis methods proved challenging for assessing vitamin A fortification in oil, but the problem was overcome with the use of the iCheck CHROMA rapid test kit. A decisive breakthrough for the vegetable oil fortification program and potentially for monitoring the quality of other fortified food vehicles, the device enabled mitigation of import delays for fortified vegetable oils and establishment of a reliable compliance system in Ghana. Going forward, from a public health perspective, an integrated approach building on the food fortification initiatives and including additional iron-fortified food vehicles should be explored to increase the amount of iron added to the Ghanaian diet, as the amount of iron intake from wheat flour fortification only cannot match the threshold reported to be efficacious. The interest of the private sector partners in expanding fortification to additional processed foods and to foods for infants and young children should also be leveraged to this end.

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