Fish sauce, soy sauce, and vegetable oil fortification in Cambodia: Where do we stand to date?

Chan Theary, Dora Panagides, Arnaud Laillou, Saphoon Vonthanak, Chheng Kanarath, Chhea Chhorvann, Pol Sambath, Sol Sowath, and Regina Moench-Pfanner

Abstract

Background. *The prevalence of micronutrient deficiencies in Cambodia is among the highest in Southeast Asia. Fortification of staple foods and condiments is considered to be one of the most cost-effective strategies for addressing micronutrient deficiencies at the population level. The Government of Cambodia has recognized the importance of food fortification as one strategy for improving the nutrition security of its population.*

Objective. *This paper describes efforts under way in Cambodia for the fortification of fish sauce, soy sauce, and vegetable oil.*

Methods. *Data were compiled from a stability test of Cambodian fish sauces fortified with sodium iron ethylenediaminetetraacetate (NaFeEDTA); analysis of fortified vegetable oils in the Cambodian market; a Knowledge, Attitudes, and Practices (KAP) study of fortified products; and food fortification program monitoring documents.*

Results. *At different levels of fortification of fish sauce with NaFeEDTA, sedimentation and precipitation were observed. This was taken into consideration in the government-issued standards for the fortification of fish sauce. All major brands of vegetable oil found in markets at the village and provincial levels are imported, and most are nonfortified.*

Conclusions. *Fish sauce, soy sauce, and vegetable oil are widely consumed throughout Cambodia and are readily available in provincial and village markets. Together with an effective regulatory monitoring system, the government can guarantee that these commodities, whether locally produced or imported, are adequately fortified. A communications campaign would be worthwhile, once fortified commodities are available, as the KAP study found that Cambodians had a positive perception of fortified sauces.*

Key words: Cambodia, challenges, fish sauce, food fortification, soy sauce, vegetable oil

Background

The prevalence of undernutrition in Cambodia is among the highest in Southeast Asia. Forty percent of children under 5 years of age are stunted, 11% are wasted, and 28% are underweight. Anemia is a critical public health problem. More than half (55%) of children aged 6 to 59 months and 44% of Cambodian women aged 15 to 49 years are anemic [1]. An estimated 30% of anemia is caused by iron deficiency [2]. Vitamin A deficiency is also of public health concern. Eight percent of women have experienced night-blindness during a previous pregnancy and 22% of children under 5 years of age are vitamin A deficient [3, 4].

Micronutrient deficiencies pose a serious public health problem, particularly among preschool-aged children and pregnant and lactating women. They have been shown to increase the risk of morbidity and mortality, impair cognitive development and growth, and decrease work productivity. Furthermore, it has been estimated that countries may lose 2% to 3% of their Gross Domestic Product (GDP) if iron, iodine, and zinc deficiencies persist [5]. An analysis of seven countries in Central America and the Dominican Republic found that economic losses due to child undernutrition, including micronutrient deficiencies, amounted to $6.6 billion, or 6% of annual GDP [6].

Fortification of staple foods and condiments is considered to be one of the most cost-effective strategies

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for addressing micronutrient deficiencies at the population level [7]. In Cambodia, fish sauce is an ideal candidate, as it is a condiment consumed by over 90% of the population [8]. Soy sauce is also a good vehicle. Unpublished surveys conducted in 2004 and 2010* suggest that 80% to 99% of the population, including pregnant women and children, consume fish sauce or soy sauce regularly. Although there are no recent published data on vegetable oil consumption, a 2010 market study conducted by the Global Alliance for Improved Nutrition (GAIN) found estimated consumption to be 3 kg per person per year, with consumption increasing by 4.7% per year [9].

There is growing evidence that iron-fortified fish sauce and soy sauce can improve serum ferritin and hemoglobin levels [10–14]. Fortification of vegetable oil with vitamin A is considered a cost-effective, simple-to-implement strategy [15]. Vitamin A, a fat-soluble vitamin, added to oil is well absorbed and can improve serum retinol levels [16]. A regional analysis of condiments and vegetable oil in Vietnam, Laos, and Cambodia showed that a potential multiple food fortification strategy was feasible because relatively few companies accounted for most of the market share of these commodities. In Cambodia, these commodities include vegetable oil, fish sauce, and soy sauce [9]. Furthermore, the study found that there is significant commercial trade between Vietnam and Cambodia. Sixty percent of the vegetable oil and 10% of the fish sauce consumed in Cambodia is imported from Vietnam [9].

The Government of Cambodia has recognized the importance of food fortification as one strategy for improving the nutrition security of its population and calls for action on food fortification within the 2008–13 Strategic Framework for Food Security and Nutrition (**box 1**). To this end, various initiatives have been undertaken, including the issuance of a government proclamation for an official label or logo to be used for iron-fortified fish sauce and soy sauce products nationwide. Furthermore, standards for iron-fortified fish sauce and soy sauce have been approved and efforts are under way to draft mandatory fortification legislation.

In July 2010, a stakeholder workshop reviewed 3 years of work related to fortification of fish sauce and soy sauce in Cambodia and concluded that iron fortification of these condiments offers a promising strategy to control and prevent iron-deficiency anemia, as was demonstrated in Vietnam, Thailand, Cambodia, and China [10–14]. With support from GAIN, the Reproductive and Child Health Alliance (RACHA), primarily funded by the US Agency for International Development (USAID), in partnership with stakeholders from the National Subcommittee on Food Fortification (NSCFF), including the private sector, is building upon and expanding efforts in Cambodia to ensure local adequate production of fortified fish sauce, soy sauce, and vegetable oil, as well as supporting government efforts at regulatory monitoring to ensure that the imports of these food vehicles are fortified. This article describes efforts under way in Cambodia for the fortification of fish sauce, soy sauce, and vegetable oil.

BOX 1. Opportunities and barriers for the fortification strategy in Cambodia

Opportunities

Wide consumption supplied by large producers

Fish sauce and soy sauce are the most widely consumed processed commercial food products in Cambodia, consumed by more than 90% of the population. Surveys suggest that producers registered by the Ministry of Industry and Mines (MOIME) may account for 48% of national consumption in 2010. Five producers account for more than half of registered production, and 34 account for more than 93%. Fortification of all registered production plus imports, accounting for 78% of current consumption, is considered feasible. With the expanding economy and roads, commercial sales are increasing by more than 8% and imports by about 3% annually. By 2015, commercial domestic and imported products, which are considered potentially fortifiable, may account for more than 90% of consumption.

Although less is currently known about cooking oil consumption habits, Food and Agriculture Organization (FAO) data suggest that consumption is rising at nearly 5% annually. Global Alliance for Improved Nutrition (GAIN) market survey data suggest that imports are increasing at 10% per year. Along with a soon to be completed domestic refinery, these trends may result in a 65% market share of commercial oil products that are potentially fortifiable.

Extensive political commitment for mandatory regulation

Based on the success of salt iodization, as well as involvement and ownership of the product development process, stakeholders from the Ministry of Planning, Ministry of Health, and MOIME, as well as the National Nutrition Council, are publically committed to achieving mandatory fortification of fish sauce and soy sauce within 3 years.

Barriers

Lack of consumer awareness

There is very little awareness of vitamin and mineral deficiencies, vitamin and mineral benefits, or even micronutrients in general across the population

Browning of fish sauce after fortification

Ensuring that the fortified food vehicle does not change organoleptic properties is important. Changes, such as browning, can hinder the uptake of the fortified food vehicle by consumers.

* Subnational surveys were conducted in 2004 by GTZ (Deutsche Gesellschaft für Technische Zusammenarbeit, the German agency for development) and in 2010 by the Reproductive and Child Health Alliance (RACHA).

Methods

In order to inform the food fortification strategy in Cambodia, various studies were conducted. The authors also used data from previous and current food fortification projects to draw findings and conclusions. The methods of the studies and projects are described below.

Stability test of Cambodian fish sauces fortified with NaFeEDTA

This study was implemented by RACHA in 2012 to determine the impact of the addition of sodium iron ethylenediaminetetraacetate (NaFeEDTA) on the characteristics of fish sauce (with a nitrogen degree between 15° and 20°N). Factors tested include whether NaFeEDTA changed the color, total nitrogen content, and precipitation of the fish sauce and the use of filtration processes with filters of differing pore sizes to reduce precipitation. The fortification dosages were 100 or 400 ppm of NaFeEDTA. Filtration was performed with cloth filters used as prefilters and cartridge filters with pore sizes of 10, 5, and 1 μm. Iron content was determined after wet digestion by a flame atomic absorption spectrophotometer (model Spectr AA-20, Varian Associates, Australia). The total soluble nitrogen content of fish sauce samples was measured by the Kjedahl method [17] and was expressed as g/100 mL. The degree of browning was monitored by diluting the fish sauce filtrate with distilled water and measuring absorbance at 450 nm. The analyses were also done after 4 months to observe the evolution over time.

Analysis of fortified vegetable oil found in the Cambodian market

Traditional cooking with lard and fish oil is disappearing, and Cambodian consumers are increasingly using vegetable oils. Vegetable oil consumption rose at a rate of 4.76% per year from 2000 to 2007 [18]. The total vegetable oil market in Cambodia in 2009 was estimated at 44,000 metric tons (MT). In 2010, the Cambodian market for vegetable oil was dominated by exports from Vietnam (60%) and Indonesia (30%).

Seventeen brands of the most common vegetable oils sold in Phnom Penh were collected at the market level by staff from RACHA and GAIN in 2012. The branded oils (packaged in plastic bottles from 250 mL to 1 L) were from Vietnam, Thailand, Indonesia, Malaysia, and Singapore. The samples were analyzed in triplicate with the iCheck-Chroma portable device. This portable device determines the concentration of vitamin A (retinol, retinyl acetate, retinyl palmitate) [19] in vegetable oil based on a color reaction described by Carr and Price [20]. Linearity of analysis ranged from 2.5 to 30 mg retinol equivalents (RE) per kilogram of vegetable oil, with 2.5 mg RE/kg being the determination limit.

Knowledge, Attitudes, and Practices (KAP) study

As part of this initiative to improve the micronutrient intake of Cambodians, RACHA undertook a baseline KAP survey at the household, village, and provincial levels to assess knowledge, attitudes, and practices in relation to iron-fortified fish sauce and soy sauce and vitamin A–fortified vegetable oil. The KAP survey was also used to determine people's perception of the availability, accessibility, and quality of these products. The survey was purposively conducted in seven provinces where RACHA had been monitoring data on its project for fortification of fish sauce and soy sauce: Kampot, Battambang, Siem Reap, Prey Veng, Kandal, Steung Treng, and Kampong Cham. Kampot and Siem Reap are the two provinces where the fortification project was first initiated. The seven provinces were the provinces that RACHA selected as the sentinel sites for monitoring its fish sauce and soy sauce project.

Data collection took place between mid-March and mid-April 2012. A multistage cluster random sampling method was used to obtain the sample. Half of the selected households were randomly selected for interview of one adult man and the other half for interview of one adult woman aged 15 to 49 years. Sample size was calculated with the Open Epi calculator. Because of the limited information about knowledge of iron-fortified fish sauce and soy sauce in the literature, we arbitrarily choose the figure of 50% in order to maximize the sample needed for this baseline survey, with a precision of 6.5% and a design effect of 1.5. As a result, the sampling included a total of 392 households per province (of a total of 2,797 households selected). The questionnaire included questions on demographic characteristics of the respondents and their knowledge and utilization of iron-fortified fish sauce and soy sauce and vitamin A–fortified vegetable oil.

If a household respondent indicated that fortified foods were used, the research team asked to see samples of the foods for verification. Each respondent signed a written consent form. Ethical approval was obtained from the National Ethics Committee of the Cambodian Ministry of Health.

At the village and provincial levels, the research team identified and listed all vendors and suppliers of fish sauce and soy sauce and then randomly selected 2 vendors from each village and 70 suppliers from each province. A total of 40 vendors of fish sauce or soy sauce were interviewed in each province.

Monitoring of project data

Besides the aforementioned studies, data from two projects were drawn upon to help inform the food

TABLE 1. Characteristics of fish sauce before and after fortification and filtration

FS condition	Total nitrogen (g/L)	Iron (ppm)	Color (absorbance)	Precipitation (%)
Fortification level 100 ppm NaFeEDTA				
Raw FS	17.248	33.79	0.634	0.22
Fortified FS passed cloth filter	17.248	118.29	0.761	0.23
Fortified FS passed at 10 μm	17.376	114.57	0.754	0.20
Fortified FS passed at 5 μm	17.104	121.21	0.753	0.22
Fortified FS passed at 1 μm	17.504	118.21	0.745	0.22
Fortification level 400 ppm NaFeEDTA				
Raw FS	17.24	40.71	1.285	0.21
Fortified FS passed cloth filter	16.82	405.84	2.218	0.22
Fortified FS passed at 10 μm	17.24	359.74	2.014	0.22
Fortified FS passed at 5 μm	16.69	370.78	2.104	0.21
Fortified FS passed at 1 μm	15.45	368.83	2.097	0.18

FS, fish sauce; NaFeEDTA, sodium iron ethylenediaminetetraacetate

fortification strategy. The first project was begun in 2005 by RACHA and NSCFF with technical support from the International Life Science Institute (ILSI) Japan. It supported the introduction of iron-fortified fish sauce and soy sauce and tested the feasibility of fortification of these food vehicles.

The current GAIN-supported food fortification project was begun in 2011 for a duration of 5 years, with RACHA as the project executing agency. The project is working with local producers of fish sauce and soy sauce and will work with the only local vegetable oil producer to ensure that their products are fortified. Activities also include the development of fortification standards, support for mandatory fortification legislation, and ensuring that government regulatory systems are in place to monitor not only locally produced products but also imports to ensure they are adequately fortified. Once production starts, the executing agency will collect data on production, quality, and other key indicators on a monthly basis in order to ensure that foods are adequately fortified. The data will be entered into a computerized database, and the results will be discussed with key stakeholders.

Results

Stability test of Cambodian fish sauces fortified with NaFeEDTA

As shown in **table 1**, the iron content in raw fish sauces varies from 33.8 to 40.7 ppm. The iron content in iron-fortified fish sauces varies from 359.7 to 405.8 ppm when fortification was expected to be 400 ppm and from 114.6 to 121.2 ppm when fortification was expected to be 100 ppm. After the addition of NaFeEDTA at a level of 100 ppm, the color does not seem to change, whereas the browning appears to increase by more than 60% before and after fortification at 400 ppm. Filtration at different filter diameters does not reduce the risk of browning after fortification. Precipitation for both fortification levels does not change after and before fortification. Over time, after 4 months (**table 2**), the fish sauce got darker as the absorbance increased from 0.4 to 0.5, but the precipitation did not increase much over time.

Analysis of fortified vegetable oil found in the Cambodian market

Samples from 17 brands of vegetable oil from markets

TABLE 2. Changes in characteristics of fish sauce before and after fortification over time

FS characteristic	Mo 1	Mo 4	Difference
Raw FS			
Color (absorbance)	1.29	1.77	0.48
Precipitation (%)	0.21	0.20	−0.01
Fortified FS passed cloth filter			
Color (absorbance)	2.22	2.64	0.42
Precipitation (%)	0.22	0.29	0.07
Fortified FS passed at 10 μm			
Color (absorbance)	2.01	2.50	0.49
Precipitation (%)	0.22	0.25	0.03
Fortified FS passed at 5 μm			
Color (absorbance)	2.10	2.59	0.49
Precipitation (%)	0.21	0.24	0.03
Fortified FS passed at 1 μm			
Color (absorbance)	2.10	2.51	0.41
Precipitation (%)	0.18	0.25	0.07

FS, fish sauce

in Cambodia found that only three were fortified, and they were fortified at various levels, with only one approaching the draft Cambodian standards for vitamin A–fortified vegetable oil (18 ppm or 60 IU/g). One Vietnamese company claimed that they fortified their vegetable oil, but the analysis did not detect vitamin A in the samples.

KAP study

Household level

During the interviews, 91.8% of participants reported that they "did use fish sauce" and 47.5% reported that they "did use soy sauce." The mean consumption of fish sauce per household per day was 74 mL (median, 63 mL), and the mean consumption of soy sauce per household per day was 57 mL (median, 45 mL). Assuming an average 5.6 individuals per family (median, 5 persons), each person consumed about 13.2 mL of fish sauce (median, 12.7 mL) and 10.2 mL of soy sauce (median, 8.0 mL). Only 2.3% of the households surveyed had at least one person consuming iron-fortified fish sauce or soy sauce. With an additional cost of 2 US cents per liter and an approximate retail price of nonfortified sauces of US$0.27 to US$2.13/L, depending on the quality, a household would pay a maximum of US$2.15/L for fortified sauces. According to the daily household consumption (74 mL of fish sauce and 57 mL of soy sauce), they would need to purchase approximately 4 L of sauces each month and thus spend from US$1.2 to US$8.6 for fortified sauces (1.6% to 11.9% of their food expenditure). This is recognized by the majority of the population (no difference between women and men) as affordable (**fig. 1**).

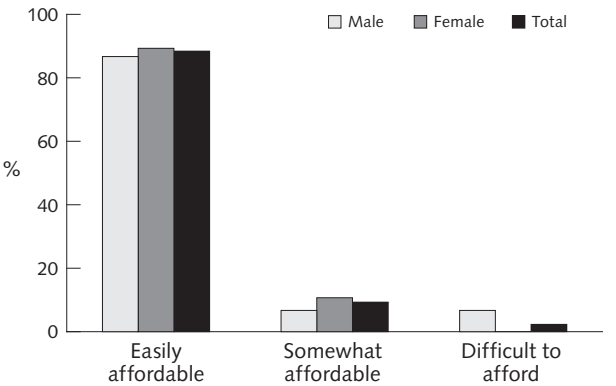

FIG. 1. Affordability of iron-fortified fish sauce or soy sauce (n = 2,797)

Only 9.7% of respondents (9% of men and 10.4% of women) had ever heard of iron-fortified fish sauce or soy sauce. The rate of knowledge varied across provinces, with the highest being Kampot (25.6%) and the lowest Prey Veng (3.8%) (**fig. 2**). As expected, knowledge of iron-fortified fish sauce or soy sauce was low across all seven provinces. Knowledge was higher in the provinces of Kampot and Siem Reap, which can be attributed to the RACHA-supported pilot project on iron-fortified fish sauce or soy sauce in these two provinces. Among those who had heard of iron-fortified fish sauce or soy sauce, 60% did not know the meaning of "iron-fortified." Most respondents (79.9%) did not know how to differentiate between containers or bottles of iron-fortified and nonfortified fish sauce or soy sauce. Most respondents (82.5%) also did not know any Cambodian brands of iron-fortified fish sauce or soy sauce products; 97% did not know any imported brands. Among those who reported currently using iron-fortified fish sauce or soy sauce, 49% had a bottle of iron-fortified fish sauce and 42% had a bottle of iron-fortified soy sauce in their kitchen. However, despite having limited knowledge about iron fortification, a high percentage of those who knew about it appeared to have a positive perception.

In addition to questions about iron-fortified fish sauce and soy sauce, questions on vitamin A–fortified vegetable oil were included in the household

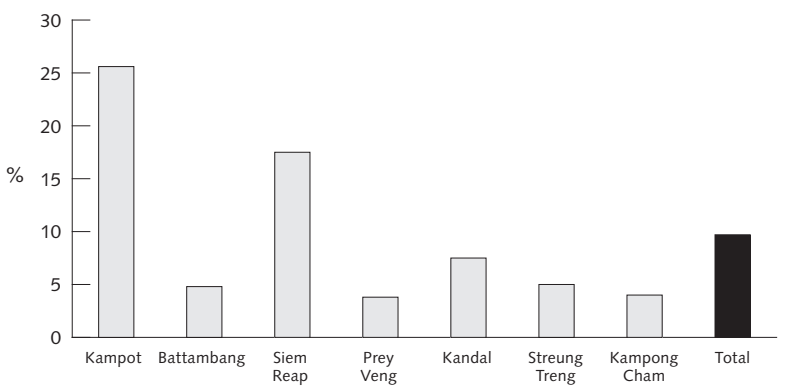

FIG. 2. Proportion of households who have ever heard of iron-fortified fish sauce or soy sauce (n = 2,797)

questionnaire. Only 10.3% of respondents ever used vitamin A–fortified cooking oil. Similar to the results for iron-fortified fish sauce and soy sauce, 62.3% did not know the meaning of "fortified," and 29% did not know whether the vegetable oil they used in the past year was fortified with vitamin A or not.

Retailers' characteristics

Nearly half of all retailers (47.4%) did not know if their fish sauce or soy sauce was fortified with iron. Among those who knew about the iron-fortified products, only 13.5% and 35.7% said they had the products available in their store at village markets and provincial markets, respectively. Among retailers of fish sauce or soy sauce, only those in Kampot and Siem Reap reported that they had iron-fortified fish sauce or soy sauce available. Nearly all retailers thought that consuming iron-fortified fish sauce or soy sauce was good for one's health, although specific reasons why were not generally known.

Project to date

The initial food fortification project with ILSI and RACHA worked with three medium- and large-scale producers to fortify 504,000 L of sauces (321,000 L of fish sauce and 183,000 L of soy sauce) with iron, a sufficient annual supply for approximately 150,000 people in Kampot, Siem Reap, and Phnom Penh. This experience showed feasibility at the producer and consumer levels. Fish sauce and soy sauce can be fortified at these facilities with the integration of simple 1- to 2-MT plastic tanks (**fig. 3**), mixers, and 1-kwh motors into the production line at a cost of approximately US$800 per facility. The addition process, mixing, and quality assurance require one or two employees for 1 hour to produce a batch of 1 to 2 MT.

To support this production, the government proclamation (Prakas) for the official label or logo (**fig. 4**) to be used for iron-fortified fish sauce and soy sauce products nationwide was approved in March 2012. On 9 July 2012, the proclamation (Prakas: 048 NCN) for production and consumption of iron-fortified fish sauce and soy sauce was approved by the Senior Minister, Minister of Planning, and Chairman of the National Council for Nutrition. The new approved Prakas allows the use of different iron fortificants, such as NaFeEDTA

FIG. 3. Cambodian plastic tank in fish sauce and soy sauce production line

or iron sulfate with citrate ($FeSO_4$ + citrate), at a level of 230 to 460 mg/L.

To formally recognize the private sector's participation in the production of iron-fortified fish sauce and soy sauce, on 20 September 2012 a Memorandum of Understanding was signed between NSCFF, RACHA, and producers of iron-fortified fish sauce and soy sauce. This was presided over by the Secretary of State, who represented the Senior Minister, Minister of Planning, and Chairman of the National Council for Nutrition. With seven approved private producers, it is estimated that the production volume of iron-fortified fish sauce and soy sauce will reach 2,851 MT in 2012/13.

FIG. 4. Cambodian nutrition communication campaign logo

Discussion

This paper describes efforts undertaken by stakeholders in Cambodia to inform the development of a food fortification strategy. As highlighted in one of the studies, fish sauce becomes darker after fortification. This change might jeopardize the success of the Cambodian program and therefore needs to be further explored. It could damage future efforts if the fortification logo is included on products that are not appealing. In 2005, Walczyk et al. [21] described this browning as the result of precipitation of the solubilized fortification iron (ferrous sulfate, ferric ammonium citrate, or ferrous lactate at a level of 5 mg/100 g) during storage either by hydrolysis or by the formation of insoluble complexes with peptides and amino acids. Fish sauce is thus technically difficult to fortify with iron. Therefore, the addition of disodium EDTA [22] or the addition of citric acid at a molar excess of about 2.5:1 relative to iron for the above-mentioned iron compounds [23] was advocated in order to bind these metal ions and limit the precipitation.

To reduce the possibility of browning, the government has issued technical standards allowing the use of citric acid or reducing the level of fortification. At 250 ppm, the change of color is expected to be minimal according to field test. Even at this level, the fortification of fish sauce and soy sauce can contribute almost 10% of the World Health Organization (WHO)-recommended iron intake (considering a low bioavailability) for women of reproductive age. This amount may not have a direct impact on iron status, but NaFeEDTA is known to enhance the absorption of both intrinsic food iron [24] and iron used in other fortified food and may have a beneficial effect on overall iron absorption from the diet. Since sauces are often consumed with rice and vegetables, fortified sauces may support additional iron absorption from these foods, not only among adults but also among children. In Vietnam, the fortification of fish sauces could contribute from 3.2% to 9.4% of the Vietnamese Recommended Dietary Allowances (VRDA) for iron [25].

Most of the vegetable oils consumed in Cambodia are imported from Vietnam or neighboring countries such as Indonesia or Thailand (**Table 3**). If local consumption is 8.2 mL/capita/day, the fortification of vegetable oil with 18 ppm of vitamin A will contribute almost 30% of the Estimated Average Requirement (EAR) for a woman of reproductive age. To date, only one brand from Indonesia has voluntarily come close to meeting Cambodian standards. One manufacturer from Vietnam claimed that they fortified their oil with vitamin A, but no vitamin A was detected in the sample. GAIN is currently supporting fortification efforts in both Vietnam and Indonesia, including fortification of vegetable oil with vitamin A. It is expected that legislation for mandatory fortification of these commodities will be imposed in both countries by 2015. Because food fortification is part of the Cambodian Government's strategy for improved food and nutrition security, mandating that oil be fortified is one way to ensure increased vitamin A intake among its population. Imports from neighboring countries will have to be fortified. Although the technology is simple, there are various factors that need to be considered to ensure that vitamin A intake by the consumer meets

TABLE 3. Vitamin A fortification levels in 17 main brands of vegetable oil

Brand no.	Origin	Date of production	Claim for vitamin A	Claim for other vitamins	Level of vitamin A fortification (ppm)
1	Malaysia	Dec 2011	No	No	ND
2	Thailand	Apr 2012	No	Vitamin E	ND
3	Indonesia	Sep 2011	Yes	No	16.5 ± 1.8
4	Vietnam	Dec 2012	No	No	ND
5	Vietnam	Jan 2012	Yes	Vitamin E	5.3 ± 0.3
6	Vietnam	Jun 2011	No	No	ND
7	Vietnam	May 2012	Yes	No	ND
8	Vietnam	Aug 2012	No	No	ND
9	Thailand	Jun 2012	No	No	ND
10	Vietnam	Jul 2011	No	No	ND
11	Vietnam	Nov 2011	Yes	Vitamin E	3.3 ± 0.4
12	Vietnam	Sep 2011	No	No	ND
13	Vietnam	Dec 2011	No	No	ND
14	Thailand	Jan 2012	No	No	ND
15	Vietnam	May 2011	No	No	ND
16	Malaysia	Jan 2012	No	No	ND
17	Singapore	Jan 2012	No	No	ND

ND, not detected

national standards. A recent study in Egypt showed that the quality of vegetable oil will have an effect on vitamin A stability. The study emphasizes the importance of reducing the peroxide value in order to improve the quality of vegetable oil to successfully fortify vegetable oils with vitamin A [26].

Challenges

In Cambodia, standards for fortified fish sauce and soy sauce have been published, and the standard for fortified vegetable oil is being drafted. Any industry voluntarily fortifying must use these standards. Mandatory legislation has not yet been enacted. This could delay the roll-out of fortified food vehicles, as not all industry partners may be willing to fortify voluntarily. A regulatory monitoring system needs to be established to effectively monitor fortification levels and ensure that when mandatory legislation is in place, the government is able to adequately enforce this. At the moment, producers can claim to be selling a fortified product, such as vitamin A–fortified oil, but there is no testing going on. An analysis conducted by GAIN found that one supplier of vegetable oil made such a claim and many are claiming that their oil is fortified with vitamins A and E. However, it is not clear whether the vitamin E added to oil is for public health reasons to protect against the long-term health risks associated with oxidative stress [27] as the packaging suggests, or just as an antioxidant (tocopherols) in edible oils [28, 29]. In order not to create confusion among consumers, it is essential to define what can be called a fortified product. The government needs to be able to test not only local production but also imports. A relatively new device, iCheck CHROMA, has recently been validated to quantitatively measure the content of retinyl palmitate in refined palm oil. It is simple to use and yields immediate results [19]. In Ghana, a significant improvement in the quality of fortified vegetable oil was observed with the introduction of this portable quantitative testing device at the port of entry [30]. This device can be used in Cambodia to enforce mandatory regulations and can easily be used at major ports where foods can be tested for compliance. The evaluation of the iCheck portable device to test the presence of iron in sauces has been implemented and shows that this device offers a viable solution for internal monitoring of iron in sauces after 1-hour and 24-hour incubations for iron sulfate or fumarate and NaFeEDTA, respectively [31]. While this research is under way, the Government of Cambodia should work on establishing a regulatory monitoring system that includes portable devices to be used by regulatory monitoring agents as well as by port officials.

Finally, although the government has recognized the importance of food fortification for the health and well-being of their population, most Cambodians are not aware of the benefits of fortified foods, and some producers may be reluctant to fortify in a voluntary fortification environment. While mandatory legislation is not yet in effect for fortified fish sauce, soy sauce, and vegetable oil, and nonfortified products are still widely available, it is important for consumers to recognize and choose fortified over nonfortified products. RACHA has conducted a KAP survey that determined general knowledge about fortified fish sauce and soy sauce to be low, even in the provinces where these food vehicles were available. Even though knowledge was low, it appears that people would be willing to spend more on fortified foods, since this would benefit their health at a minimal increase in cost over their normal food expenditures. Investing in communication campaigns to raise consumer awareness could increase uptake once availability is guaranteed.

Sustainability

Industrial and commercial sustainability

The fortification strategy is designed to be sustainable prior to the end of the project. While the incremental cost is acceptable and invisible (ranging from 0.2% to 2% of the unfortified cost, depending on the product), this price rise will be easily absorbed in overall inflation and market costs. Given the acceptable cost, mandatory legislation, and creation of broad political, business, and consumer support, the common belief is that the market can sustain cost recovery for the long term through continued consumer willingness to pay the additional cost. Although premix will initially be procured through the GAIN Premix Facility, the project design includes identifying, building capacity, and transferring responsibility for premix procurement and distribution to the industry. Therefore, by the end of the project, premix procurement and financing should be proceeding on a sustainable basis.

Policy sustainability

In Cambodia, the government has already shown interest in paving the way for fortification legislation by developing Prakas for the fortification of sauces. However, more recent data on the prevalence of vitamin and mineral deficiencies are needed in order to support an advocacy piece about the importance of legislation of mandatory fortification for sauces and vegetable oil and perhaps other staples as well.

Next steps

Technical standards and quality control will be the key components to achieve the objectives. By 2015, when the mandatory fortification law is fully implemented and enforced, fortification standards will become part of the industry licensing and registration processes. In Cambodia, it is anticipated that a national decree on

general requirements for mandatory food fortification will be approved and signed by the Prime Minister in 2014. This will provide basic enabling powers for the Ministry of Health, the Ministry of Industry and Mines, the Ministry of Commerce, and other appropriate agencies to enact mandatory fortification. Once the legislation is in place, two government agencies will be involved in the external control of the fortified products as focal points. The project will provide equipment, technical expertise, and training to these agencies.

CAMCONTROL is a division of the Ministry of Commerce that is charged with regulation and inspection of imported goods. The 300 inspectors in all 24 provinces and at international border points (including ports) will request certificates of origin and fortification and, when necessary, send samples to CAMCONTROL laboratories.

The *Ministry of Industry and Mines (MOIME)* is the controlling authority for the food industry that establishes product standards, awards business licenses, and registers products. MOIME will develop a flexible, performance-based inspection system based on quarterly inspections with frequency increasing or decreasing depending on the performance of the individual producer. Provincial lab capacity has been built in major cities (e.g., Siem Reap, Phnom Penh, and Kampot). The project will undertake intensive capacity-building of MOIME inspectors during the first 2 years of the project, with continuing annual review workshops during the final 3 years.

Failure of some fortification programs to become sustainable can be attributed in part to weak industry motivation and government political commitment and law enforcement capacity, which is reflected in inefficient or nonexistent quality assurance/quality control and monitoring systems. Although quality assurance of the fortified product is clearly the responsibility of industry, a regular government monitoring system at production plants, retail stores, and households is indispensable [32]. As discussed previously, the development of portable devices for a first screening of the quality of the various fortified foods will be an asset for the government and the producers to be more proactive.

Conclusions

Fish sauce, soy sauce, and vegetable oil are widely consumed throughout Cambodia and are readily available in provincial and village markets. These are good vehicles for fortification with iron (fish sauce and soy sauce) and vitamin A (vegetable oil). Cambodian fortified fish sauce will exhibit sedimentation and coloration at various levels of fortification with NaFeEDTA and over a period of time. However, fortification of fish sauce is feasible, as is the fortification of soy sauce, particularly if the appearance does not change, which can be achieved by adjusting fortification levels. The government has issued standards for fish sauce that take into consideration findings from the study conducted by RACHA in 2012 on the impact of fortification of Cambodian fish sauces with NaFeEDTA. It is now imperative that mandatory legislation be enacted as soon as possible for fish sauce and soy sauce as well as vegetable oil. If and when an effective regulatory monitoring system is established, the government can guarantee that not only locally produced products but also imports are adequately fortified. A communications campaign would be worthwhile to create demand, once fortified commodities are available, since the KAP study found that Cambodians had a positive perception of fortified sauces. This paper shows that the national food fortification strategy in Cambodia needs to support local production of fish sauce and soy sauce as well as regulating imports of these commodities and imports of vegetable oil to ensure adequacy of fortification.

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References

1. National Institute of Statistics, Cambodia Demographic and Health Survey. Calverton, Md, USA: Macro, 2010, 2011.
2. Giovannini M, Sala D, Usuelli M, Livio L, Francescato G, Braga M, Radaelli G, Riva E. Double-blind,

placebo-controlled trial comparing effects of supplementation with two different combinations of micronutrients delivered as sprinkles on growth, anemia, and iron deficiency in Cambodian infants. J Pediatr Gastroenterol Nutr 2006;42:306–12.
3. Cambodian National Micronutrient Survey. Phnom Penh: Helen Keller International, 2000.
4. Cambodia Demographic and Health Survey. Phnom Penh and Calverton, Md, USA: National Institute of Public Health/National Institute of Statistics/ORC Macro, 2005, 2006.
5. Horton S, Alderman H, Rivera JA. Hunger and malnutrition. Copenhagen: Copenhagen Consensus Center, 2008.
6. El costo del hambre: impacto economico y social de la desnutricion infantile. Santiago, Chile: United Nations Economic Commission for Latin America and the Caribbean (CEPAL)/World Food Programme, 2007.
7. Allen L, de Benoist B, Dary O, Hurrell R. Guidelines on food fortification with micronutrients. Geneva: World Health Organization/Food and Agriculture Organization, 2006.
8. Ranum P. Report of mission: opportunities for micronutrient fortification of foods in Cambodia. Phnom Penh: UNICEF, 2001.
9. Global Alliance for Improved Nutrition. Vegetable oil and condiment report. Ho Chi Minh, Vietnam: GAIN, 2010.
10. Longfils P, Monchy D, Weinheimer H, Chavasit V, Nakanishi Y, Schümann K. A comparative intervention trial on fish sauce fortified with NaFe-EDTA and FeSO4 + citrate in iron deficiency anemic school children in Kampot, Cambodia. Asia Pac J Clin Nutr 2008;17:250–7.
11. Thuy PV, Berger J, Davidsson L, Khan NC, Lam NT, Cook JD, Hurrell RF, Khoi HH. Regular consumption of NaFeEDTA-fortified fish sauce improves iron status and reduces the prevalence of anemia in anemic Vietnamese women. Am J Clin Nutr 2003;78:284–90.
12. Van Thuy P, Berger J, Nakanishi Y, Khan NC, Lynch S, Dixon P. The use of NaFeEDTA-fortified fish sauce is an effective tool for controlling iron deficiency in women of childbearing age in rural Vietnam. J Nutr 2005; 135:2596–601.
13. Chavasit V, Nopburabutr P, Kongkachuichai R. Combating iodine and iron deficiencies through the double fortification of fish sauce, mixed fish sauce, and salt brine. Food Nutr Bull 2003;24:200–7.
14. Chen J, Zhao X, Zhang X, Yin S, Piao J, Huo J, Yu B, Qu N, Lu Q, Wang S, Chen C. Studies on the effectiveness of NaFeEDTA-fortified soy sauce in controlling iron deficiency: a population-based intervention trial. Food Nutr Bull 2005;26:177–86; discussion 187–9.
15. West KPJ, Darnton-Hill I. Vitamin A deficiency. In: Semba RD, Bloem MW, eds. Nutrition and health in developing countries, 2nd ed. Totowa, NJ, USA: Humana Press, 2008:377–433.
16. Dutra-de-Oliveira JE, Fávaro RM, Junqueira-Franco MV, Carvalho CG, Jordão Júnior AA, Vannucchi H. Effect of heat treatment on the biological value of beta-carotene added to soybean cooking oil in rats. Int J Food Sci Nutr 1998;49:205–10.
17. Helrich K, ed. AOAC official method of analysis. Washington, DC: Association of Official Analytical Chemists, 1999.
18. Food and Agriculture Organization. FAOSTAT. Available at: http://faostat.fao.org/. Accessed 26 February 2013. Food and Agriculture Organization. FAOSTAT. Available at: http://faostat.fao.org/. Accessed 26 February 2013.
19. Rohner F, Frey SK, Mothes R, Hurtienne A, Hartong S, Bosso PE, Bui M, Schweigert FJ, Northrop-Clewes C. Quantification of vitamin A in palm oil using a fast and simple portable device: method validation and comparison to high-performance liquid chromatography. Int J Vitam Nutr Res 2011;81:335–42.
20. Carr FH, Price EA. Colour reactions attributed to vitamin A. Biochem J 1926;20:497–501.
21. Walczyk T, Tuntipopipat S, Zeder C, Sirichakwal P, Wasantwisut E, Hurrell RF. Iron absorption by human subjects from different iron fortification compounds added to Thai fish sauce. Eur J Clin Nutr 2005;59:668–74.
22. Fidler MC, Davidsson L, Walczyk T, Hurrell RF. Iron absorption from fish sauce and soy sauce fortified with sodium iron EDTA. Am J Clin Nutr 2003;78:274–8.
23. Chavasit V, Nopburabutr P, Kongkachuichai R. Combating iodine and iron deficiencies through the double fortification of fish sauce, mixed fish sauce, and salt brine. Food Nutr Bull 2003;24:200–7.
24. MacPhail AP, Patel RC, Bothwell TH, Lamparelli RD. EDTA and the absorption of iron from food. Am J Clin Nutr 1994;59:644–8.
25. Laillou A, Mai LB, Hop LT, Khan NC, Panagides D, Wieringa F, Berger J, Moench-Pfanner R. An assessment of the impact of fortification of staples and condiments on micronutrient intake in young Vietnamese children. Nutrients 2012;4:1151–70.
26. Laillou A, Hafez SA, Mahmoud AH, Mansour M, Rohner F, Fortin S, Berger J, Ibrahim NA, Moench-Pfanner R. Vegetable oil of poor quality is limiting the success of fortification with vitamin A in Egypt. Food Nutr Bull 2012; 33:186–93.
27. Bramley PM, Elmadfa I, Kafatos A, Kelly FJ, Manios Y, Roxborough HE, Schuch W, Sheehy PJA, Wagner KH. Vitamin E. J Sci Food Agric 2000;80:913–38.
28. Frankel EN. Antioxidants in lipid foods and their impact on food quality. Food Chem 1996;57:51–5.
29. Lampi A-M, Kataja L, Kamal-Eldin A, Vieno P. Antioxidant activities of α- and γ-tocopherols in the oxidation of rapeseed oil triacylglycerols. J Am Oil Chem Soc 1999;76:749–55.
30. Nyumuah RO, Hoang TC, Amoaful EF, Agble R, Meyer M, Wirth JP, Locatelli-Rossi L, Panagides D. Implementing large-scale food fortification in Ghana: Lessons learned. Food Nutr Bull 2012;33(4 suppl): S293–300.
31. Laillou A, Icard-Vernière C, Rochette I, Picq C, Berger J, Sambath P, Mouquet-Rivier C. Rapid quantification of iron content in fish sauce and soy sauce: a promising tool for monitoring fortification programs. Food Nutr Bull 2013;34:S123–31.
32. Dary O, Mora JO, International Vitamin A Consultative Group. Food fortification to reduce vitamin A deficiency: International Vitamin A Consultative Group recommendations. J Nutr 2002;132(9 suppl):2927S–33S.