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Seeking Optimal Means to Address Micronutrient Deficiencies in Food Supplements: A Case Study from the Bangladesh Integrated Nutrition Project

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Abstract

In seeking to improve the micronutrient content of a food supplement used in a major community-based nutrition project in Bangladesh, operations research was conducted to compare the provision of needed micronutrients through additional food sources (fresh or dried fruits or vegetables), a micronutrient multi-mix, or a combination of the two. Using a standard food fortification method, micronutrient gaps were estimated for four groups of project beneficiaries. Cost-delivery and bulk constraint analysis were then utilised to compare options. In terms of these analyses, the micronutrient multi-mix proved by far to be the most advantageous. While, in addition to the multiple benefits of food per se, food options are unquestionably desirable in terms of sustainability and the value of increasing demand to boost domestic fruit and vegetable production for the population as a whole, it is clearly cost-effective to use powdered micronutrient mixes for such specific purposes as supplementary food enrichment and food fortification.

Background

While there has been considerable ideology supporting food and non-food approaches in addressing micronutrient deficiencies, there has been remarkably little empiricism. This study represents an effort to fill this important gap, and in so doing help us move forward on this issue with some common purpose.

The Bangladesh Integrated Nutrition Project (BINP), now covers 12% of the country, and is presently being expanded into a national program. One of the components of this integrated project involves daily, on-site supplementary feeding for four beneficiary groups: young children who are growth faltering or severely malnourished, and pregnant or lactating women who have a low body mass index. Unlike many other food supplements, the BINP food supplement has been designed as an educational tool to demonstrate the importance of complementary food to mothers, to indicate an easy way to feed their children and themselves, and to promote growth. The choice was made at project inception to process the supplement locally by women's groups for the purpose of local income generation instead of processing it centrally by a food company. The supplement is made from roasted rice flour, roasted lentil powder, molasses, and oil, and is packaged in units called "*pushti*" packets, i.e., nutrition packets.

The BINP food supplement, however, is deficient in micronutrients. Therefore, it is neither an appropriate therapeutic food, nor an appropriate demonstration food. The goal of this operations research was to identify the optimal means of increasing the micronutrient content of the BINP food supplement in order to make it appropriate to the needs of the beneficiaries.

The government asked that this operations research explore alternative possibilities of meeting this micronutrient gap. We considered providing vegetables or fruit (fresh or dried), a micronutrient multi-mix, or some combination of the two. The food options had the advantage of being sustainable and serving as a valuable education and demonstration tool. Yet, uncertainty was raised about feasibility, because of the large quantity of fruits and vegetables that would be needed. Indeed, covering adequate amounts of micronutrients, particularly vitamin A and iron, two deficiencies typically considered important public health problems in developing countries, might require large amount of produce.

This article includes the results of the first phase of the operations research and focuses on the review of the options to increase the micronutrient content of the food supplement. A second phase then involved the feasibility testing of the option selected.

Methods

The study was carried out jointly by the Institute of Nutrition and Food Science (INFS) of Dhaka University and the School of Nutrition Science and Policy, Tufts University. Phase 1 of the study was divided into two parts: (1) micronutrient gap analysis and (2) cost-delivery and bulk constraint analyses.

The team determined the micronutrient gaps for the four BINP beneficiary groups by using a methodology commonly used for food fortification (Beaton, 1994). For each planned micronutrient, it was assumed that the distribution of intakes of that nutrient by a given population group was normal, and means and standard deviations were taken from published sources (Jahan, 1998; Ahmed, 1993). To these theoretical nutrient intakes, we added the nutrient intake from the BINP food supplement and subtracted the estimated amount of food substituted as a result of supplementation. This calculation was done separately for each beneficiary group.

Using a calculation of nutrient density for each planned nutrient and each population group (Beaton, 1999), a method that was validated for the Bangladesh context by Desplats, an estimation was made of the nutrient density of a fixed amount of supplement capable of ensuring that a pre-determined percentage of the population would consume at least the requirements for that nutrient. We then determined reference nutrient intakes for each group of beneficiaries based on their average intakes so that 99% of the children and 95% of the mothers would receive the full RDA of each micronutrient (Beaton, 1999). We defined the "micronutrient gaps" as being the difference between estimated micronutrient intake and the reference nutrient intake.

In order to meet the vitamin A and iron gaps identified in this first phase, the team compiled a list of locally available fruits and vegetables with the highest content of those two micronutrients. Assessments then were made of each identified fruit and vegetable in terms of cultural acceptance, market price, and seasonal availability in order to provide a practical list to nine readily available, accessible and acceptable fruits and vegetables.

Given the importance of bulk in consumption by young children, the team then explored opportunities to reduce the bulk from these fruits and vegetables. We considered solar drying with dryers made from locally available materials, a low cost technology developed and validated by the Mennonite Central Committee, for its capability for rapid drying during the rainy season.

For the short-listed nine fruits and vegetables, a computerised model was developed using Excel spreadsheets. This model included up to six parameters (vitamin A or iron content[i], bio-availability of the micronutrient[ii], loss during processing, edible portion of the raw food[iii], percentage of dried matter[iv], and average market price between peak and lean season[v]), and estimated the cost and the amount of food required to meet vitamin A and iron reference nutrient intake per *pushti* packet. Since the precise bio-availability of iron in particular foods is uncertain, we conducted a sensitivity analysis with a range of values.

Results

Micronutrient gap

Because data on age specific nutrient consumption in Bangladesh is relatively scarce, estimates were taken from two sources (Jahan, 1998; Ahmed, 1993). Analysis of the micronutrient content of the BINP food supplement was carried out by INFS (Brown, 1998). For nutrients that could not be tested, estimations of nutrient content were taken from the literature (INFS; Gopalan, 1989; USDA, 1999).

Feedback from project implementation staff indicated that beneficiaries of the food supplementation were consuming the entire food supplement allocated to them, i.e., one *pushti* packet per growth faltering child, two per severely malnourished child, and four per pregnant or lactating woman. At the same time, based on international data on supplementary feeding programs, the team estimated that, due to consumption of the project's food supplement, women would consume the equivalent of 400 fewer kcal at home (Adair, 1985). Since 80% of the adult Bangladeshi diet consists of rice (Jahan, 1998), the team worked with an assumption that all the food displaced for mothers would be rice. For children, it was assumed that 75 kcal would be displaced, consisting of 50 kcal of rice and 25 kcal of breast-milk.

By comparing daily nutrient intakes and daily requirements, nutrient gaps and per packet requirements were estimated (see Table 1).

Cost-delivery and bulk constraint analysis

Cost-delivery and bulk constraint analysis based on the previously determined gaps were carried out for vitamin A and iron only, on the assumption, proven valid, that conclusions could be drawn from these two nutrients alone. Several parameters included in the previously discussed model are provided in Table 2 below. The team made the conservative assumptions that all the vitamin A would be bio-available, and that the bio-availability of iron varied from 10% to 50%[vi]. Estimates used for vitamin retention during drying and cooking were 68.8% and 63% respectively, while a figure of 100% retention was used for iron (Mulokozi, 1997; Rahman, 1990).

At this point in the operations research, Table 2 was discussed in a meeting with BINP officials and INFS research staff. The meeting concluded that based on cost and bulk considerations, further analysis of the fresh and dried food should be carried out with *lal shak* (red spinach) only.

The team then calculated total costs required to cover the vitamin A and iron gaps for 1,000 Community Nutrition Centres (CNC) for one year (see Table 3). Data from BINP implementation staff indicated that, on average, each CNC feeds two severely malnourished children, ten growth faltering children, and twenty pregnant or lactating women each day. This means that, on average, each CNC would require 94 *pushti* packets per day, for the 25 days a month it functions. Calculations were made in Bangladeshi *taka* and then converted to US dollars using the conversion rate of Tk. 48 for US $1.

The cost for the multi-micronutrient mix, $3 per 1,000 *pushti* packets, was taken from estimates provided from Indian suppliers.

As indicated in Table 3, the cost of the multi-mix, meeting all major micronutrient requirements, is a small fraction of the cost of the fresh or dried *shak* required to meet only vitamin A and iron requirements. Even making the audacious assumption of 50% iron absorption from *lal shak*, the cost of fresh or dried *shak* would be nearly 10 times higher; at 10% iron absorption, the cost would be nearly 50 times higher. To meet these needs with eggs—an option suggested by one BINP official—would require 0.7 to 2 eggs per *pushti* packet per day. At the 50% absorption level, eggs would cost 25 times and at the 10% absorption level, they would cost 125 times the cost of the multi-mix.

Fresh *shak*, at the 50% absorption level, would more than double the bulk of the food supplement, while at the 10% absorption level it would increase the bulk over 10 fold.

Discussion

Although the cost-delivery of the multi-mix is more attractive than fresh or dried food for purposes of enhancing the micronutrient content of the BINP food supplement, broader benefits of fruits and vegetables[vii], coupled with the sustainability of food-based options[viii], argue for creative ideas to bolster such approaches.

In the context of the food supplement, for example, an alternative to the multi-mix alone might be the use of fresh *lal shak* to meet the vitamin A gap (increasing the cost of meeting this gap by only 40% while increasing supplement bulk by less than a third) while using the multi-mix to address the iron and other gaps.

By contrast, drying the *shak* or providing eggs would not be feasible. Beyond the high cost involved, drying with solar dryers would require the installation of multiple dryers at each site, the expenses of training in their use, and the cost of maintenance. The limitation for the eggs option, beyond the cost, would be the regular supply of a large quantity of eggs.

Conclusion

The results indicate a distinct cost-delivery advantage to providing the needed micronutrients in the BINP food supplement through a powdered multi-mix as opposed to the addition of other foods, or perhaps, as suggested above, through some combination of the two. In addition to the major cost differential, the amount of fresh food necessary to meet these micronutrient gaps would far exceed the capacity of young children to consume such bulk. The expense and logistics of the food drying option would be prohibitive. While the project should continue to promote intensively the consumption of micronutrient-rich foods and to encourage home garden production of micronutrient-rich foods, it may be unrealistic to use fruits and vegetables exclusively for the narrower purpose of enriching the food supplement.

Considered more broadly, the use of powered micronutrient mixes for such specific purposes as supplementary food enrichment and food fortification appears fully justified. In resource-scarce developing economies, it would be foolhardy to bypass such attractive and cost-effective opportunities. At the same time, given the enormous value of food-based approaches as discussed above, national governments should take all possible steps to encourage the production and consumption of micronutrient-rich foods, through combinations of behaviour-change communications and sustainable home-gardening activities. Research and program efforts to make these food-based options viable sources of micronutrients for even the poorest households should be encouraged.

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Table 1. Micronutrient Gaps

Nutrient	*Amount of nutrient needed per 100g of food supplement*	*Amount of nutrient needed per pushti packet (38g)*
Iron (mg)	2	0.76
Ca (mg)	300	114
Zn (mg)	4.4	1.67
Vitamin A (RE)	400	152
Vitamin C (mg)	2.0	7.6
Riboflavin (mg)	0.5	0.19
Niacin (NE)	2.2	0.84
Vit. B 12 (μg)	0.4	0.3

Table 2.
Assessment of Nine Nutrient-Rich Locally Available Fruits and Vegetables by Parameters Used in the model

	Vitamin A content in 100g of edible portion	***Iron Content in 100g of edible portion***	***Edible portion of raw food***	***% of dry matter***	***Average market price per Kg of raw produce***
	(RE)	(mg)	(%)	(%)	(Tk)
Data Shak (Leafy vegetable)	1,000	1.80	40	19	5.00
Pui Shak (Leafy vegetable)	1,240	1.14	40	19	6.00
Helencha Shak (Leafy vegetable)	2,283	n/a	40	19	9.00
Lal Shak (Leafy vegetable)	1,990	1.80	40	19	6.50
Borboti (Cow pea)	94	5.90	100	11	17.50
Gajor (carrot)	315	2.20	100	13	17.50
Mishti Kumra (Sweet pumpkin)	1,200	0.70	80	9	11.00
Paka Pepe (Ripe papaya)	170	0.50	80	15	n/a
Amra (Hog plum)	45	3.90	80	15	27.50

Table 3.
Annual Costs Needed to Meet the Vitamin A and Iron Gaps for 1,000 Community Nutrition Centres and Quantities of Food Added per *Pushti* Packet

		Total Cost (US$)	***Bulk added per pushti packet***
Multi-mix		84,600	negl.
Fresh lal shak	Vitamin A	117,500	12g
	Iron 50% [a]	804,875	84g
	Iron 10% [b]	4,212,542	422g
Dried lal shak	Vitamin A	423,167	4.8g
	Iron 50% [a]	804,875	16g
	Iron 10% [b]	4,212,542	80g
Egg	Vitamin A	1,239,625	0.7
	Iron 50% [a]	2,150,250	1.2
	Iron 10% [b]	10,633,750	2

a. If iron bio-availability = 50%
b. If iron bio-availability = 10%

Notes

[i] Gopalan, 1989
[ii] MCC, 1999; Rahman, 1990
[iii] MCC, 1999
[iv] MCC, 1999
[v] MCC, 1999
[vi] INFS estimates that the absorption of iron would not exceed 5%, considering the lack of an absorption enhancer such as vitamin C in the Bangladeshi diet and the presence of inhibitors such as tannins. Nonetheless, the team used "conservative" estimates of 10% and 50% in a sensitivity analysis to provide the "benefit of the doubt" to the food-based options.
[vii] Some scientists argue that "foods contain, besides the vitamins that we know of, a whole range of bioactive phytochemicals... which are known to have beneficial effects on health." (Gopalan, 1999).
[viii] While food-based solutions often enhanced sustainability, it would be erroneous to assume that the multi-mix option necessarily implies imports. Although an imported product was utilized in this operations research, large-scale production for a national program would almost certainly generate local production.