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SHARING UNITED STATES TECHNOLOGY TO AID IN THE IMPROVEMENT OF NUTRITION

BANGLADESH WHEAT ATTA FORTIFICATION

Report on the Feasibility Assessment
Conducted December 4-16, 1999

by

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EXECUTIVE SUMMARY

This report assesses the feasibility of producing micronutrient fortified wheat atta (flour) in Bangladesh and introducing it into the Food for Education (FFE) program.

The point of departure for the assessment was a brief document prepared by USAID/Dhaka in July 1999 that proposed to replace the FFE monthly wheat grain ration with a fortified and packaged wheat atta ration. This proposal was later endorsed and a pilot program was proposed in the G/PHN/HN--MOST project trip report. These reports viewed wheat atta to be the most likely candidate for fortification in Bangladesh and the FFE program an excellent means of reaching about two million low-income families with nearly 300,000 metric tons of fortified food each year.

The assessment was conducted in December of 1999 by a three person field team consisting of Thomas Marchione, Nutrition Advisor of the Bureau for Humanitarian Response, Peter Ranum, Milling and Fortification Expert, with SUSTAIN, and Shahidur Rahman Bhuiyan, Economist in USAID/Dhaka's EGAD division. Samuel Kahn, Senior Health/Nutrition Advisor for the Health and Nutrition Office in G/PHN also advised the team on the analysis and preparation of the report. The Office of Program, Planning and Evaluation in the Bureau for Humanitarian Response funded the assessment.

The assessment is based on the review of key documents and a set of interviews with government officials, NGOs, and the food industry. The team also observed milling operations at six mills located in Dhaka, Chittagong, and Naryanganj areas, and reviewed results of the analyses of samples of flour collected from these mills.

This report concludes that distribution of fortified wheat atta in place of whole wheat in the FFE program is technically achievable and would be an effective means to deliver deficit micronutrients to a particularly vulnerable group in Bangladesh. It suggests that fortification could moderate the high prevalence of iron deficiency anemia and vitamin A deficiency, as well as deficiencies of folic acid, zinc, and riboflavin among program recipients. The report includes an analysis showing that the consumption of 75 grams of fortified atta every day by a school age child, could safely provide from 25 to 75 percent of their recommended dietary intake of these micronutrients.

Because of the low food consumption in Bangladesh and the depth of poverty in the county, the team advises that the design of the fortification intervention must ensure that present favorable household food security and educational impacts of the FFE program are maintained or strengthened. The present wheat allotments for FFE recipients' households represent over 25 percent of their monthly incomes, a clear incentive to parents to send their children to school.

The team found a variety of wheat milling standards and practices in the country, ranging from thousands of traditional, neighborhood *chakki* mills to 260 modern roller mills. The team found the modern milling sector had the capacity to fill the wheat atta requirements of the FFE program. Although millers had no experience with fortification, they expressed an intense interest in producing fortified atta and modifying their production facilities to do so. In addition, at least one Bangladeshi premix manufacturer for the feed industry appeared capable and interested in producing the fortification premix required for the program.

The added production costs per year to process, fortify, and pack bulk wheat into fortified atta for 5 FFE pilot districts is estimated at US$850,000 (Tk 42 million). If the estimate was expanded to include all 64 FFE districts, production costs are estimated to be US$10.8 million (Tk 538 million). The fortification premix component included in these estimates is projected to cost US$168,000/year for 5 FFE pilot districts or $2.2 million for all districts. The estimates for additional costs to millers for processing and packing the wheat into atta is based on conversations with millers. These costs, however, are very rough estimates and will be better determined from what is learned during the pilot. Until the government and millers actually negotiate the price of the fortified atta, the cost cannot be projected with a full measure of confidence.

To help launch the pilot phase of this program, some additional start-up costs need to be considered. Initial costs for capital equipment, consumer studies, product development studies, and training of one or two Bangladeshis in fortification technology in the U.S. is estimated to be from $220,000 to $270,000. These costs would be added to a more comprehensive planing and pilot budget that will include costs for technical assistance, project management, on-going quality control, and local training, which the team did not estimate.

The team recommends that USAID/Dhaka undertake the following actions:

1. Actively pursue a three-phase process for implementing the wheat atta fortification proposal, as follows: (1) a planning phase, (2) a pilot phase in five FFE district sites, and (3) an expansion phase into all FFE districts. The estimated time frame for implementation of the three-phase process is 36 months, 12 months for each phase.

2. Expand and accelerate the effort to inform key local officials of the benefits and safety of micronutrient fortified atta to the low income FFE families and secure an agreement to produce the fortified atta on a limited basis.

3. Secure a financing agreement between the MOE, MOF, and the private millers that includes a price millers will charge for the fortified atta and how the available wheat resource will be used, either by direct distribution to millers or through sales.

4. Fund technical assistance and training during all three phases of the project. Begin by sending to the United States one Bangladeshi technologist for training in milling and fortification. As the project progresses, enlist the assistance of premix manufacturers (international and local) to work with millers on fortification technologies.

5. Conduct separate focus group interviews during the planning phase with samples of school teachers and FFE recipient households to assess attitudes toward the proposed change in the ration from 15 kilogram of wheat grain to 12 kilograms of wheat atta. Inquiries with FFE grain distribution dealers also should be conducted to obtain similar information.

6. Commission a rapid survey to determine the actual levels of wheat consumption by households and how FFE food rations are currently allocated among household members. Lay the groundwork for measuring the cost effectiveness of this program as a means of

reaching poor Bangladeshi families with benefits. If possible, to save time and cost, perform these actions together with recommendation number five.

7. Evaluate a premix formula that would add the following four nutrient levels: 100 parts per million (PPM) iron in the form of ferrous fumarate, 50 PPM zinc in the form of zinc oxide, 4 PPM riboflavin, 2 PPM folic acid, and 10,000 IU per kilogram of vitamin A in the form of SD250 protected vitamin A palmitate. The team further recommends that in order to enhance iron absorption, 300 PPM of disodium EDTA be added and that the ash content of the atta be specified as having a maximum of 0.7 percent. Consideration should be given to adding additional B vitamins to atta with this ash specification, and the addition of sodium iodate should also be considered.

8. Commission organoleptic studies to detect and eliminate any perceptible changes in the fortified atta that are disagreeable to future consumers, and commission stability studies to determine the retention of vitamin A in fortified atta and *chapatis* prepared from it.

9. Provide premix samples and specifications to Bangladeshi manufacturers who presently produce vitamin/mineral premix products and request that they produce a high quality product at reasonable cost. Import the premix until their capability is demonstrated.

10. In cooperation with the MOE, select five FFE school districts for the pilot program that are reasonably representative of the whole program to test and model the fortification effort.

11. Fund the cost of needed equipment and the premix for the pilot phase of operations. Install ingredient feeders at three large modern roller mills (capacities of 100 metric tons daily or more) to serve three districts and construct two batch mixing facilities in two districts with smaller roller mills. Purchase well designed modern equipment from U.S. manufacturing companies for use in the pilot program. Where there would be no conflict with intellectual property rights, assist other Bangladeshi millers to procure, adapt, or model equipment at their own expense when they decide to participate in the expanded program.

12. Arrange for the supply of unfortified wheat atta to batch mixing facilities from smaller roller mills. Approach millers' association for this purpose.

13. Implement three quality control procedures: (1) atta production reports and audits of premix purchases; (2) analytical testing of products for marker nutrients; and (3) development of "iron spot" test kits for verifying fortification by FFE schools, atta production facilities, and FFE rations distribution centers.

14. Contract with a capable laboratory in Bangladesh for routine wheat atta micronutrient testing during the planning and pilot phase of the project.

15. Provide assistance to the Bangladesh Standards and Testing Institution (BSTI) to establish and publish a fortified wheat atta standard.

16. Assist the Ministry of Industry and/or other regulating agency to develop a memorandum of understanding with an existing capable laboratory in Bangladesh for long term quality

assurance testing and producer licensing. Equipping a government laboratory with the necessary analytical equipment is not recommended at this stage.

17. At the end of the pilot phase, conduct a review of all results so that the expansion phase may be entered into smoothly.

18. Establish a project team to deal with all aspects, including the food and nutrition issues, economics and financing, and institutional relationships. The team should be adroit at advising the GOB on the cost effectiveness of the project. As appropriate, make use of the technical assistance of the MOST project for assistance in overall technical management, and use the SUSTAIN project to assist in training, testing, product development and initiation of the pilot.

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ABBREVIATIONS AND ACRONYMS

BHR	Bureau for Humanitarian Resources
BHR/PPE	Bureau for Humanitarian Resources/Office of Program, Policy, and Evaluation
BSCIC	Bangladesh Small and Cottage Industries Corporation
BSTI	Bangladesh Standards and Testing Institution
CARE	Cooperative for American Relief Everywhere
CDIE	Center for Development Information and Evaluation
CDRB	Center for Development Research, Bangladesh
CIDA	Canadian International Development Agency
CHO	Carbohydrate
DPC	Development Planning Consultant
EGAD	Economic Growth and Agricultural Development
EDTA	Ethylenediaminetetraacetate
FAO	Food and Agriculture Organization
Fe	Iron
FFE	Food for Education
FPMU	Food Planning and Monitoring Unit
GOB	Government of Bangladesh
FMRSP	Food Management and Research Support Project
G/PHN	Bureau for Global Programs/Population, Health &Nutrition Center
G/PHN/HN	G/PHN/Office of Health and Nutrition
GNP	Gross National Product
HES	Household Expenditure Survey
HKI	Helen Keller International
HPLC	High Performance Liquid Chromatograph
ICCIDD	International Council for Control of Iodine Deficiency Disorders
ICDDR-B	International Center for Diarrheal Disease Research-Bangladesh
IFPRI	International Food Policy Research Institute
IFST	Institute of Food Science and Technology
INFS	Institute of Nutrition and Food Science
IPHN	Institute of Public Health Nutrition
IU	International Unit
IVACG	International Vitamin A Consultative Group
JECFA	Joint Expert Committee on Food Additives
MOE	Ministry of Education
MOF	Ministry of Food
MOST	USAID's Micronutrient Operations Strategies and Tactics project.
NGO	Non-Governmental Organization
NNP	National Nutrition Program
NSP	National Surveillance Program
PA	Phytic Acid
PPM	Parts Per Million
RD	Rural Development
RDI	Recommended Dietary Intake
SD	Standard Deviation
SUSTAIN	Sharing United States Technology to Aid in the Improvement of Nutrition
Tk	Taka
UNICEF	United Nations Children's Fund
USAID	United States Agency for International Development
UNU	United Nations University
VGD	Vulnerable Group Development
WFP	World Food Program
WHO	World Health Organization
Zn	Zinc

I. INTRODUCTION AND BACKGROUND

A. This Assessment

The purpose of this assessment is to determine the feasibility of producing micronutrient fortified wheat atta (flour) in Bangladesh and introducing it into the Food for Education (FFE) program.

At present no food staples, other than salt, are routinely fortified with micronutrients in Bangladesh. In July 1999, USAID/EGAD/Dhaka, with the assistance of the IFPRI Food Management and Research Support Project (FMRSP), circulated a proposal to distribute fortified wheat atta in place of wheat grain in the Ministry of Education's Food for Education (FFE) distribution program. The fortified atta would be processed and packaged by Bangladeshi millers.

In September 1999, the G/PHN/HN--MOST cooperative agreement completed a general assessment of potential micronutrient fortification in Bangladesh, reviewing a wide range of possible candidate foods for fortification. That assessment identified wheat atta fortification as an attractive means for adding micronutrients to the diet of lower income and nutritionally needy people in the country. The MOST assessment endorsed and further developed the USAID FFE proposal.

This assessment was subsequently requested by USAID/Dhaka to explore more completely the feasibility of going forward with the proposed changes in the FFE program, particularly in light of questions regarding the technology of milling and fortification. Funding was provided by BHR/PPE through the G/PHN/HN--SUSTAIN cooperative agreement.

B. The Food for Education Program

The Bangladesh Ministry of Education (MOE) runs the FFE program, which started in 1993. Its purpose is to increase the enrollment and reduce the dropout rate of children from low-income families in the primary education cycle, ages 5–11 years old. The program entitles a family with one child in primary school to 15 kg of wheat monthly, and with two or more children in the school to 20 kg of wheat monthly. The program is fully funded by the GOB, and the food is given free as an incentive so that the children will attend school and stay in school instead of working to generate income for their families.

Each month FFE district grain dealers distribute wheat to recipient student families. The families take the wheat to local *chakki* mills where it is milled into whole-wheat atta at an estimated payment of Tk 0.5 to 1.0 per kg. (The exchange used in this report is 50 Taka equal to one US dollar.) Payment may also be made in kind with a portion of the flour, probably around 10 percent. Some recipients will sell the wheat or the flour for cash. There is also opportunity for leakage, pilferage and sale of the wheat during distribution. It is not known how much of the wheat is actually consumed by the recipients; however, the recipient wheat sales apparently do not interfere with the primary objective of the FFE program.

Expansion of this program has been swift, tripling in size since its inception (see Annex A). A 1999 assessment by the Bangladesh Center for Development Research showed that FFE was implemented in 1,243 unions (communities) providing benefits to about 2,296,000 students from about 2,182,000 poor families, containing approximately 10-12 million people. That study, along with other independent studies, has concluded that the program has been effective at reaching poorer families and markedly improving student attendance and retention and reducing drop outs as intended. At its maximum 270,000 MT of wheat, worth about US $50 million, have been annually distributed under this program, one-third of which comes from USAID PL480 Title II though CARE, who sells it to the Ministry of Food (MOF). The rest originates in other countries or is locally produced.

C. Proposed Changes in the FFE Program

The USAID/IFPRI proposal recommends that the FFE program distribute fortified and packaged atta twice per month in place of bulk wheat grain once per month. The implied purposes for the change are the following: (1) to improve the food distribution system, (2) to use wheat atta for delivering deficit micronutrients to the recipients, and (3) to make the food more convenient to use.

The proposal states that the 15 kg of grain provided to a family with one student would be replaced with approximately 12 kg of atta per month. (For a family with more than one student, the amount would be presumably 16 kg per month in place of 20 kg of grain.) The original proposal assumed that this reduction of 20 percent would result from the direct conversion of the wheat into wheat atta at a 95 percent extraction rate. The proposal also assumed, that the reduction of overall food to families would be off set because packaging and labeling would enhance the propensities of families to consume rather than sell the ration. The reduced ration would be acceptable to the families because their time and the cost for milling would be saved and chances of pilferage in the distribution would be reduced. This assessment questions some of these assumptions.

IFPRI estimated that the production of whole wheat flour (atta) with a 90-95 percent extraction rate will add approximately Tk 2.5 (5 US cents) per kilogram of wheat due to milling, cost of fortification, and packaging. This assessment provides different estimates of the extraction rate. Although the report confirms the added cost estimate, it finds the net cost of the production to the Ministry of Education impossible to estimate without further information.

Visits with public and private sector leaders by IFPRI field supervisors and subsequent interviews by Kamal Hyder of the MOST project discovered a receptive environment for the FFE idea. IFPRI also found that the milling capacity exists in Bangladesh to absorb the additional wheat milling that this project would eventually demand. This assessment found support for both of these findings.

The MOST report developed the fortification concept further by proposing a pilot program. The pilot would begin in 8-10 sites before going to full scale in all 64 FFE districts, after approximately 18 months. The report outlined an initial budget from $455,000 to $500,000 to cover premix, equipment, technical assistance missions, and a local field staff. The report also recommended a task force to be formed jointly by the Ministry of Food and the Ministry of Education with participation by the USAID/Dhaka and a technical assistance team to

select the 8-10 sites for a pilot program. This assessment has further developed the pilot concept and revised the cost estimates and timeframe.

II. ASSESSMENT OF PROJECT ACCEPTABILITY

A. Political and Cultural Climate

The team feels there is sufficient government and private sector support to obtain a waiver from the Ministry of Industry to begin wheat atta fortification on a limited basis, although the wheat atta fortification proposal is not fully accepted by officials we spoke to. This will require an expanded effort to inform key official of the safety and benefits of micronutrient fortified wheat atta.

A previous effort by USAID and HKI to fortify wheat grain in Bangladesh in the late 1980s failed to take off because of technical difficulties associated with fortifying bulk grain, questions about its cost effectiveness, and lack of support from Bangladeshi authorities. At that time there was no experience with fortification in the country, and fears and suspicions about donor initiated fortification efforts ran high. As one person involved in the earlier project put it: The effort failed " . . . because of overly aggressive action by the U.S. Mission and concern over 'foreign' interference with food supply."

Fortunately, over the past decade, convincing work has been done by nutritionists and others to demonstrate the importance of nutrition in the improvement to health and productivity of the country. Specifically, the recent experience with the universal iodization of salt, spearheaded by UNICEF, has created a more receptive environment for consideration of fortification alternatives. The team found that salt iodization was a familiar starting point for discussing the fortification of wheat atta with academics, government officials, and the private sector. Public sector institutions were not only aware but also sometimes involved with the iodization program in one way or the other, and were generally supportive, although aware of the quality control problems being experienced.

Milling companies and one pharmaceutical company were eager to move forward. There was only minimal concern that the distribution program could represent commercial market competition between mills. They were familiar with obtaining wheat for milling from government sources, a practice common under previous government ration systems.

Yet, the fortification idea has not been fully accepted by all local officials. Some policy makers questioned how detectable fortificants would be to consumers and stressed the need for thorough consumer acceptance testing. We were informed of opposition by at least one prominent medical expert at the Institute of Child and Maternal Health. Technical specialists questioned potential for toxic overdosing from fortification, particularly because of the multiple and overlapping vitamin A supplementation programs already underway.

The underlying cultural concern with purity and whiteness, which has a symbolic religious basis in much of south Asia, is also a potential obstacle. Purity and whiteness was valued in marketing slogans, differential price(s), and qualitative assessment of white (*maida* and *suji*) versus darker "red" whole wheat flours (atta). This implies a preference for low ash, roller mill atta over *chakki* mill atta. Pure food legislation, presently in force, explicitly requires that wheat flour " . . contain only substances which are derived exclusively from wheat . . . ."

This prohibition is repeated in the published atta standard, but the standards for *maida* allow the addition of minute qualities of bleach or other ingredients. We were informed that the legal obstacle has been identified and the Ministry of Health and Family Welfare is reviewing the legislation for possible revision. The passage of the universal iodization legislation in the 1990s has set a favorable policy precedent on fortification of the food supply in Bangladesh, which could help clear the way for fortified atta.

The recent World Bank aide memoir addressing the Bangladesh National Nutrition Program (NNP) addresses the technical problems of iodine fortification. Yet the plan sets a long time horizon for implementing fortification of centrally processed food stuffs. The Bangladesh National Plan of Action for Nutrition sees food fortification as a key strategy for overcoming micronutrient malnutrition. Legislative guidelines for lawmakers will be drafted under NNP-I (2000-2004), and, once legislation is passed, improved standards for testing and quality management will be pursued under NNP-II .

Support from other donors for the concept was encouraging. WFP is eager to cooperate with USAID on this effort, and is seeking a consultant from CIDA to investigate fortification of up to 300,000 metric tons of wheat they distribute annually in food for work and vulnerable group development (VGD) programs. Similarly, UNICEF officials, quite forthcoming on their iodization effort and complementary feeding program, were also eager to cooperate.

B. Recognized Nutrition Problems in Bangladesh

The team found that serious micronutrient deficiencies persist in Bangladesh that should be addressed by fortification. Most prominent were the problems of worsening iron deficiency anemia and persistent vitamin A deficiency. While vitamin A deficiency has declined in recent decades, it continues to be a serious problem among children and mothers. The team also found support for addressing folic acid, zinc, and riboflavin. Iodine deficiency, although it is being addressed by salt fortification, continues to be a vitamin deficiency of major development significance. Vitamin C was the only other micronutrient in which there was expressed interest.

The team believes that micronutrient deficiencies must be dealt with in the context of low food consumption and food insecurity in Bangladesh, particularly among the lower income households receiving food transfers.

In discussions with Bangladeshi food and nutrition professionals and international NGOs, the team found general consensus on the major nutrient deficiencies in Bangladesh. Problems have been documented in nationally representative food consumption and nutrition surveys done in 1962-64 and 1995-96, and in rural sample surveys in 1975-76 and 1981-81, along with the national vitamin A survey done in 1997-98 (Table 1). The top two panels of Table 1 show the extent of low dietary intake of energy and three critical nutrients. The top panel shows the daily per capita intake and the gap between intake and requirements for school age children and pregnant women according to FAO/WHO/UNU standards. The second panel shows that most people in the country have less then adequate intake levels for all nutrients, and that the gap may be considerable in some groups. The final panel summarizes other evidence of nutritional shortfall.

Dietary energy: School age children are consuming many fewer calories than the recommended intake for their age group, particularly children under 10 years of age. Low dietary energy, along with infection, contributes to the underweight and stunting of over half of the children under five. Child underweight is associated with over half of all child deaths in Bangladesh.

Table 1. Estimates of Major Nutritional Problems

Groups	Daily Intake Per Capita of School Age Children and Pregnant Women							
	Calorie		Iron		Vitamin A		Riboflavin	
	Kcal	%Req.*	mg	%Req.	IU	%Req.	Mg	%Req.
4-6 years	1146	71	7.4	50	1046	80	.30	30
7-9 years	1408	76	9.4	55	1200	92	.39	30
10-12 years	1722	93	10.9	66	1578	99	.44	30
Pregnant	1856		10.8	20	1174	59	.46	33
	Other Evidence of Nutritional Problems, All Groups							
Percentage of individuals with inadequate nutrient intakes	>65%		>90%		>50%		>98%	
Evidence	Over half of under fives are stunted (<2sd below reference standard)		Hemoglobin levels <11gm/100 ml in all rural age groups except males over 15 years of age		Persistence of night blindness in women. Low serum retinol levels in pregnant women.		Overall prevalence of angular stomatitis and scaring is 47%.	

Sources: Institute of Nutrition and Food Science, University of Dhaka 1998; HKI 1999
* The requirements are derived from WHO/FAO/UNU expert consultations as cited and discussed by the Institute of Nutrition and Food Science in the "Bangladesh National Nutrition Survey, 1995-96."

Vitamin A: Signs of vitamin A deficiency have diminished over the past two decades, but the deficiency continues to be a serious problem, particularly among pregnant and lactating women. The prevalence of night blindness, keretomalacia, Bitot's spots, and corneal scarring have dropped below the WHO threshold for public health significance, probably in response to universal supplementation of young children. However, serum retinol levels are low, representing substantial biochemical vitamin A deficiency; 22% of preschool children and 45-50% of pregnant women are below the WHO/IVACG reference levels.

The main dietary origin (85 percent) of vitamin A in Bangladesh is from beta-carotene in leafy and non-leafy vegetables, which is less efficiently converted to vitamin A than formally thought and absorption is also probably low because of low dietary oil consumption. Consequently, the consumption figures shown in Table 1 probably overestimate vitamin A status. Vitamin supplementation reaches most preschool children, but not other age groups. Improving the vitamin A status of deficient children can have marked beneficial impact on their mortality risks. Similarly, maternal mortality rates in Bangladesh are among the highest in the world, and there is some evidence from Nepal that vitamin A may prevent a substantial portion of that mortality also.

Iron: Over 90 percent of Bangladeshis have low iron intakes, and school-age children consume not much more than half of their daily requirements according to the latest national survey (Table 1). Associated anemia has risen and has become a much more serious problem over the past thirty years. Over fifty percent of the dietary iron is derived from cereal

sources, especially rice, and to a much lesser extent wheat. Most other food sources of iron are of vegetable origin. Heme iron from animal-source foods makes up less than one-tenth of intake. Although wheat provides three to four times the dietary iron than rice, like rice whole wheat is abundant in inhibitors, particularly phytates, which prevent the absorption of the iron into the body. Thus, Bangladeshis with diets principally of cereals and inadequate amounts of animal-source foods, has a high prevalence of anemia.

Iodine: According to a national goiter survey done in 1993, 47 percent of the population had palpable goiter due to iodine deficiency. A recent evaluation of the fortification program found that much of the iodized salt being marketed does not contain sodium iodate at adequate concentrations, and many families do not consume iodized salt. More recent studies of urinary iodine levels suggest that the national salt fortification program may not have reduced the prevalence of iodine deficiency as much as had been anticipated. Widespread iodine deficiency could have greater long-term effects on mental development and productivity than other micronutrient deficiencies in Bangladesh. Children of iodine deficient mothers have high risks of cretinism and milder forms of mental deficit that affect their capacity for productive work as adults.

Riboflavin: Deficiency in this vitamin is particularly evident among the B vitamins, and is increasing in prevalence. School age children consume only 30 percent of their daily requirement and the national survey shows that nearly the entire population has inadequate consumption of this nutrient (Table 1). This may be connected to the rice consumption replacing vegetable consumption in diets already low in animal products. A clinical sign associated with this deficiency is skin lesions around the mouth, e.g., angular stomatitis, which are probably perceived by sufferers to be more serious than they actually are. Severe deficiencies have not been reported and other functional consequences are generally mild or unknown.

Zinc: This mineral is getting more attention everywhere, and although there is no direct biochemical measures of zinc deficiency, it tends to accompany iron deficiency. Zinc deficiencies, like iron deficiencies, are associated with stunting, and zinc is important in the conversion of beta-carotene into vitamin A. Its deficiency may partly explain the low serum vitamin A in Bangladesh despite rising consumption of leafy vegetables (ICDDR-B, personal communication).

Other deficiencies: Although thiamin intake is low there is no reported evidence of beriberi, an endemic disease among rice eating populations in Asia. In Bangladesh 80-90 percent of these B vitamins are received from cereal sources. Vitamin C intake is also quite low and although there are clinical signs, such as bleeding gums (5%), no major scurvy problem is found. Calcium intakes could also be improved, and some evidence of its deficiency is suggested by anecdotal reports of rickets in pockets of the rural population.

C. Consumer Acceptance

The substitution of wheat atta for wheat grain should be acceptable to the recipients and it should assist in the continuing success of the FFE program.

This acceptance hinges on the actual and perceived value of the wheat atta to the student's household. Key to that acceptance is the equivalence of wheat atta and wheat grain in terms

of calories and market value. For most recipient families, the FFE wheat grain represents at least 25 percent of their monthly income, which is probably key to reducing the opportunity cost of sending their children school.

For purposes of the assessment, this team has assumed that the monthly ration of wheat grain (of 15 kg or 20 kg) could be replaced with a smaller amount of wheat atta (12 kg or 16 kg) because the market value of the wheat atta will be greater than the wheat grain it replaces. However, the acceptability of this reduction to recipients and the calorie reduction offset from the higher propensity to consume wheat atta must be confirmed at the community level during the planning phase.

The success of the wheat atta distribution effort depends on acceptance by the recipients. First of all, the consumers in the FFE program must be willing to receive wheat atta in place of wheat grain. This assessment was unable to determine if such a substitution would be acceptable to the families of the students receiving wheat grain rations at present. In the absence of such information, good arguments can be found for and against the substitution. Fortified atta would be more nutritious than unfortified atta, it will save families the trouble and expense of milling, and it will be distributed in packets of known weight, which, we are told, will be less subject to pilferage than bulk grain handling. Atta may be more likely consumed than traded because of its shorter shelf life. Wheat can be stored for a year or longer under proper conditions, while, according to our sources, wheat atta may begin to show infestation, mold or other signs of deterioration in a few months or less.

Wheat grain on the other hand offers a poor family advantages that wheat atta does not. Wheat's longer shelf life makes it more tradable. Stored wheat can serve, as a kind of family savings account, being sold or traded as needed for other foods or goods required for family survival. This process might enhance the food security and nutrition of the family as much or more than the consumption of the wheat itself. In this way wheat grain may be a better vehicle of income transfer to the poor household than is wheat atta.

While we do not know which of these arguments better fits the desires of the recipients, we do know that the FFE program is successful, and that success should be enhanced or at least preserved when changes are made to the program. Attractive packaging and promotion of the benefits of fortification are obviously necessary. Recipient households should perceive the wheat atta as better or at least equivalent in value to that of wheat grain. Since wheat also serves dietary energy and other economic needs, recipient households must receive wheat atta rations that actually provide similar overall caloric value and overall market value compared to the wheat grain rations it replaces.

These considerations are as important, perhaps more important, in determining the amount of food to be distributed to each student as is the micronutrient considerations. Therefore, distribution of not less than 12 kg (three two-kilogram bags two times per month to one-student families) or 16 kg (for families with more than one student, four two-kilogram bags twice per month), could replace the present ration of 15 kg or 20 kg of wheat grain. This represents a one-fifth reduction in weight but only a one-eighth (12.5 percent) reduction of caloric content of the ration, which will probably be off-set by the families' consuming a greater portion of the wheat atta ration than the portion of the wheat grain ration they presently consume.

The market value of atta is higher than that of the same weight of grain, which might compensate for the reduced size of the ration. The market equivalence is very important because of the low income of the recipients. Over two-thirds of FFE families have monthly incomes below Tk 500.[1] The value of distributed wheat grain at current market prices represents at least 25 percent of the monthly income of the student's family. For example, if the market price of grain was Tk9/kg, the family could sell half its monthly ration of 15 kg for Tk 68, leaving 7.5kg for consumption. After milling by the *chakkiman*, for 1 Tk/kg, this would leave perhaps 7 kg and Tk.60 for the family. On the other hand, if the market price of packaged wheat atta was Tk 14.5/kg, the family could sell 4 kg monthly atta ration for Tk 58, leaving 8kg of a more nutritious food for consumption.

These however, are speculative figures. For purposes of judging consumer acceptance, there is no substitute for direct inquiry of potential recipients. These should involve attitudinal inquiries with FFE households and schools about the substitution of packaged wheat atta for wheat grain. Similar inquires should also be done with district FFE dealers who are not distributing the wheat rations to the recipient families. Therefore, we recommend that focus group interviews be done as soon as possible to aid in the planning effort. Each group, households, schools, and dealers should be interviewed separately to avoid biased responses. The results should help identify the appropriate package size, appearance and labeling. Thought should be given to selecting a symbol (logo) identifying the product as more potent and healthy than unfortified atta.

The other major acceptance consideration, which was raised by the Joint Secretary of the Ministry of Food and other officials, is that fortification should not change the readily observable properties of the wheat atta. The fortification of the atta should not affect its taste, odor, appearance, or shelf life in undesirable ways. Therefore we recommend that once premix formulae are selected, a panel of potential FFE recipients should be set up for organoleptic testing of the wheat atta and *chapatis* made from them. Premix formulae should be adjusted according to organoleptic results.

D. Projected Consumption of Wheat Atta

The lack of survey data hindered the team's estimate of the projected consumption of wheat atta by FFE households. The best estimate, based on available information, is that the program could realistically expect a target consumption of 75 grams per capita per day of fortified wheat atta for the school age during months that distribution is taking place. This amount may vary widely, but consumption of more than 300 grams per capita per day on a sustained basis appears to be very unlikely. These estimates must be replaced with more accurate figures from household consumption surveys of FFE recipients during the project planning phase. Both the total household consumption and the distribution of food among members should be better estimated.

Rice is the staple food in Bangladeshi households but wheat plays a growing role in the diet. Cereals contribute 74 percent of the per capita calorie requirement, with over 95 percent

[1] Based on figures reported July 1999 by the DPC Group of Consultants in the report, "Comprehensive Assessment/Evaluation of the Food for Education Program." Per capita GNP in Bangladesh in 1998 was $240 per year or roughly Tk 1000, so clearly the FFE program is reaching a low-income segment of the population.

being from rice. Significantly, however, wheat is more likely to be consumed by lower income and more nutritionally vulnerable households, although this less of a distinction than it used to be. For instance, we now believe that most urban and semi-urban families consume *chapatis* with their breakfasts. Wheat is also widely distributed in relief situations.

For purposes of this assessment it is necessary to estimate the consumption of wheat by the FFE household since no direct survey data could be found. This was done in two ways: to examine the results of surveys in similar distribution programs and make approximations of consumption based on the rations amounts currently distributed in the FFE program (Table 2).

Table 2. Wheat Consumption Estimates daily per capita intake (grams per day)

	All Households		Recipients of Food Aid Wheat Grain		FFE Distributed Amounts
	INFS Survey 1995-6	NSP Divisions 1998	WFP VGD 1999	HES Survey 1999	12 kg/mo Wheat Atta Projected
Rural	20			97	
Overall	18	11-33	86(70)*		75**

Sources: Derived from national nutrition survey conducted by the Institute of Nutrition and Food Science, HKI, National Surveillance Program (NSP), L.Keiss (personal communication), IFPRI Analysis of Household Expenditure Survey (HSP)
* 70 grams of the wheat consumed was program wheat, 16 grams are from market purchase.
**For children, according to the assumptions discussed in the text.

Although the average consumption of wheat across the country is low, the consumption by recipients of wheat from aid programs is much higher. Household recipients of wheat through the WFP Vulnerable Group Development (VGD) program consume 86 grams per person per day, most of which (70 g) is the wheat provided to them by the program. According to the Household Expenditure Survey (HES) rural households receiving wheat transfers consume 97 grams per capita, with a standard deviation of nearly 100. From this variation, we infer consumption of up to 250 grams per day on a sustained basis may be common for some individuals, roughly five *chapatis* per day, while consumption of 300- 400 grams per person would be unlikely to rare. Consumption of 400 grams would be about 80 percent of a primary school-aged child's whole energy requirement and approximately 60 percent of an adult's requirement, not likely to be the case in a diet where rice is the preferred cereal.

Another way to estimate consumption can be guessed from the amounts distributed. According to the wheat atta proposal, a FFE family with one student would receive 12 kg of fortified atta per month (Table 2, left panel). (Although families with more than one student will receive 16 kg, over 90 percent have only one student in school.). This amounts to 80 grams per capita per day, if distributed evenly among a five person household. However, in the VGD program, recipients consume about 50 percent of the wheat grain they receive monthly, presumably they lose, trade, or give away the rest. As assumed in the previous section, perhaps only one-third of the more valuable and more perishable wheat atta ration will be sold or given away, leaving 8.0 kg for household consumption. Divided over thirty days that would supply a family 267 grams per day or only 53 grams per capita per day, if it is equally divided in the average family. However, assuming that families understand that

children are the intended beneficiaries, a target of 75 grams would not be unreasonable to expect.

Therefore, considering both the projected distribution and the consumption survey data for food aid recipients shown in Table 2, further analysis in this report projects the consumption of 75 grams of fortified atta per child per day, roughly one and one-half *chapati*. If a child from 6-10 years of age consumes this amount, over half of his or her average daily calorie shortfall would be filled.

Clearly, it is of critical importance to know how much of the ration will be consumed and how much traded away for other foods or goods. Although substitution of wheat atta for wheat grain, according to this proposal, would reduce the total calories delivered to the household by about 12.5 percent, this could be readily compensated for if families do have a greater propensity to consume wheat atta and by less pilferage in distribution and handling. The question also remains, will children receive disproportionately more of the ration? Consequently, the75 gram estimate must be confirmed or replaced with a more accurate estimate from household consumption surveys of FFE recipients during the project design phase. Both the total household consumption and the distribution of food among members should be better estimated by rapid consumption survey methods.

ASSESSMENT OF PRODUCTION FEASIBILITY

A. Production of Wheat Atta in Bangladesh

1. Wheat milling technology

The team found a variety of wheat milling standards and practices ranging from thousands of traditional, neighborhood chakki mills to 260 modern roller mills throughout the country.

There are two types of mills in Bangladesh, traditional *chakki* mills and modern roller mills. *Chakki* mills are small stone mills usually owned by one entrepreneur. There are thousands of *chakki* mills in Bangladesh, located in markets or in any commercial area. They can mill a few metric tons per day if they are operated continuously, but they normally only operate when customers bring grains or pulses to be milled or when the miller purchases wheat to be milled for some customers. These millers, or *chakkimen*, operate one or more stone mills and charge from Tk 0.5 to Tk 1.0 (1 to 2 cents) to mill a kilo of wheat, or they will take a portion (about 10%) of the flour as payment. Wheat brought to *chakki* mills is often quite dirty containing dirt, sticks, stones, straw and other impurities called "dockage." Dockage can be 4% or more depending on the origin of the wheat. *Chakkimen* may "clean" the wheat by employing someone to pick out the more obvious impurities, particularly the stones or anything hard that may damage his mill. The wheat is then ground between two rotating stones, as has been done for a couple thousand years, except the stones are normally rotated by electric motors instead of using hydro or animal power. The flour produced, called "atta," is made up of the whole wheat plus any contaminates, since there is generally no sifting of the flour after milling. This flour is high in iron in forms that may not be well utilized. Some of that iron is present as the oxide, which can not be absorbed by the body, and much of the remainder may not be well absorbed because it is tied up by phytic acid, which is at a high level in whole wheat flours.

Modern roller mills are much larger than *chakki* mills; they have a daily milling capacity of 20 to 150 MT of wheat. There are about 260 roller mills in Bangladesh. Most of these mills, and nearly all with capacities over 50 MT/day, have equipment to clean the wheat and remove the dockage prior to milling. The cleaned wheat is then tempered by adding a small amount of water and letting it soak in overnight. This softens the bran making it easier to remove. The tempered wheat is run through grinding rolls that crush the wheat. After the rolls the ground wheat is run through sieves and purifiers producing a number of fractions differing primarily in size. Some of these are sent back to milling rolls for additional grinding and others are combined to make final products. A roller mill uses a gradual reduction process to separate the inner wheat endosperm, which is primarily starch and protein, from the outer bran layers, which is largely cellulose. From 100 kg of dirty wheat a roller mill might produce the following:

- 4 kg of wheat cleanings
- 20 kg of bran
- 78 kg of flour

The reason these add up to more than 100 kg is because of the water added during tempering. The extraction rate or flour yield in this mill would be 78%. Most roller mills in Bangladesh have an extraction rate in that area.

Roller mill production is further broken down into the following products:

- The ***bran*** can be either large in size or fine like flour. Bran, along with some of the organic cleanings, is usually sold as animal feed, since only animals can digest it.
- The flour can be all straight grade flour or separated out into three distinct products:
  - ***maida*** flour is the purest, whitest flour made by not including the higher ash flour streams, or from 5 to 15% of the total flour, called *clears*.
  - ***atta*** is the clears, or the residual from making maida.
  - ***suji*** is farina, or large chunks of pure endosperm. If ground to flour it would become maida, so the more suji the less maida.

The atta produced by roller mills is quite different from that produced by *chakki* mills in that it would normally contain less bran. It would also be much more variable in its composition and nutritional content, depending on how it is made. Some mills may use only the highest ash streams, called *red dog*, which has a very high mineral and vitamin content, even higher than that of whole wheat or wheat atta. Other mills make a premium atta by including more maida, which reduces its micronutrient content.

The Bangladeshi published standards for atta and maida flour are shown in the following table. The standards for atta are very comprehensive, with a high maximum value for ash. This allows atta to be nearly any type of flour produced in rollers mills, from a low ash white flour to a high ash clear or *red dog* fraction.

Table 3. Bangladesh Flour Standards

Characteristic	Units	Atta	Maida (LG)
Moisture	Maximum %	14.0	13.0
Ash, total	Maximum %, dry basis	2.0	0.7
Ash, acid insoluble	Maximum %, dry basis	0.1	0.05
Gluten	Maximum %, dry basis	7.0	7.0-8.0
Fiber, crude	Maximum %, dry basis	2.0	--
Alcoholic acidity	Maximum %	0.1	0.1
Granularity	Micron sieve 100% through	600	180

Source: Bangladesh Standard Specification for Atta (first revision), BDS 380:1980, September 1990 and Bangladesh Standard Specification for Maida (first revision), BDS 381:1980, July 1986, Bangladesh Standards & Testing Institution (BSTI).

2. Nutritional analysis of atta samples

Analysis of atta samples collected in Bangladesh showed that much of the atta produced by roller mills was of a lower extraction with a lower ash content than that produced by chakki mills. Improved iron absorption and shelf life can be achieved by specifying a low maximum ash content in the atta used in the FFE program.

During their visit to Bangladesh the assessment team collected nine atta samples shown in Table 4. One of these, number 6, was a *chakka* mill atta taken at a Dhaka open air market. The others were all from roller mills. These samples were sent to a commercial analytical laboratory in the United States for testing. The tests included three minerals (phosphorus, zinc and iron), phytic acid, and proximate nutritional analysis. The latter includes measuring the major constituents of moisture, ash, protein, fat and total fiber. Carbohydrates (CHO) are then calculated by difference and energy (calories) is calculated from these values.

The results on the *chakki* mill sample (#6) are similar to that of whole wheat flour as would be expected. Its iron content is high enough (26.9 ppm) to supply 20% of a child's iron requirement (10 mg/day) with a 75 gram/day consumption. However, its high phytic acid content (0.49%) and high phytate/iron molar ratio (15) indicates that the iron would be poorly absorbed. The situation for zinc is worse since the zinc content (10.9 ppm) is lower and the phytate/zinc molar ratio (43) higher.

Two of the eight roller mill samples (#3 and #7) have higher ash contents than the *chakki* mill atta. These would be considered clear flours. They have high iron and zinc contents but they would not be well absorbed because of their very high phytic acid levels. The other six roller mill atta samples have a much lower ash content that could actually fall under the maida standards. These have much lower phytic acid levels but their mineral content is also low leaving the phytate/mineral molar ratios still high enough to seriously inhibit absorption.

The results showed high correlation between a flour's content of ash, minerals, phytic acid and even fat, as shown by the correlation coefficients given in Table 5. Correlations greater than 0.95 allows good prediction of one value from the other, the higher the value the better the prediction. This is useful since ash is the easiest and least expensive test to run. The correlation between ash and phytic acid is 0.993 allowing ash to be used to predict phytic acid. By specifying a maximum ash content, phytic acid, which inhibits iron absorption, can be keep down to acceptable levels.

Keeping a low ash specification on the atta used in the FFE program would not only improve iron absorption but it would also help extend shelf life and reduce possible flavor problems, which result mainly from the fat content. The higher the ash, the higher the fat content, as shown by the correlation coefficient of 0.983. Considering that six of the eight roller mill atta samples had ash content below 0.7%, it would appear possible that around that value could be made the maximum ash specification on FFE atta.

Table 4. Nutritional Analysis on Atta Samples Collected in Bangladesh

Sample	P	Zn	Fe	Mois-ture	Ash	Prot.	Fat	CHO	Fiber	Phytic acid	Cal.	molar ratio for	
No. and Mill/Location	ppm	Ppm	ppm	%	%	%	%	%	%	%	kcal	**Iron**	**Zinc**
1. Noorani – Dhaka	932	4.8	9.9	13.1	0.524	10.8	1.23	74.3	2.8	0.145	352	12	29
2. Government mill – Taken at Dhaka market	1170	7.0	18.1	12.6	0.697	10.1	1.34	75.3	4.7	0.210	353	10	29
3. Fouji – Chittagong	2340	17.7	31.2	14.3	1.170	12.3	2.52	69.7	6.0	0.620	351	17	34
4. Prince – Narayaganj	1000	5.7	9.7	12.9	0.535	11.2	1.46	73.9	3.6	0.200	354	18	34
5. Khistia – Narayaganj (Suji atta)	1080	5.9	13.7	13.6	0.632	10.8	1.59	73.5	3.9	0.220	351	14	36
6. Chakka mill at Dhaka market	1690	10.9	26.9	10.6	1.090	11.6	2.38	74.4	7.7	0.490	365	15	43
7. Mark – Narayaganj	2720	21.7	38.3	12.4	1.640	11.2	3.20	71.5	12.7	0.880	360	19	39
8. Khaja Baba – Narayaganj	980	5.0	11.0	13.4	0.597	11.5	1.49	73.1	3.7	0.210	352	16	41
9. Government mill (fine atta)	725	3.6	8.3	12.6	0.451	9.3	1.28	76.3	2.8	0.092	354	9	24

Table 5. Correlation Coefficients between Analytical Values on Atta Samples

	P	Zn	Fe	Mois-ture	Ash	Prot.	Fat	CHO	Fiber	Phytic acid	Cals.	PA/Fe	PA/Zn
Zn	0.997	1.000											
Fe	0.979	0.970	1.000										
Moisture	-0.046	-0.024	-0.190	1.000									
Ash	0.979	0.973	0.985	-0.213	1.000								
Protein	0.590	0.552	0.525	0.163	0.517	1.000							
Fat	0.968	0.962	0.960	-0.198	0.983	0.574	1.000						
CHO	-0.783	-0.776	-0.676	-0.479	-0.672	-0.825	-0.708	1.000					
Fiber	0.897	0.895	0.919	-0.366	0.964	0.369	0.937	-0.505	1.000				
Phytic acid	0.989	0.986	0.973	-0.137	0.993	0.577	0.990	-0.740	0.942	1.000			
Energy	0.425	0.403	0.529	-0.907	0.568	0.148	0.579	0.085	0.674	0.517	1.000		
PA/Fe molar ratio	0.670	0.660	0.571	0.049	0.648	0.804	0.717	-0.765	0.622	0.714	0.313	1.000	
PA/Zn molar ratio	0.454	0.406	0.477	-0.317	0.526	0.717	0.578	-0.444	0.544	0.532	0.544	0.734	1.000

3. Potential for Fortifying wheat atta for the FFE program

Although the team found no evidence that nutrients or other improvers were presently being added to flour by the millers, installation of ingredient feeders (dosifiers) to large modern roller mills (over 100 MT/day) would allow them to produce fortified atta using continuous processes.

Adding micronutrient premix continuously is not feasible in the many smaller roller mills (of around 50 MT/day capacity) since their atta steams are of insufficient volume to ensure uniform addition. However, it would be possible for them to pool their atta production and fortify it at local batch mixing facilities.

The team found that both automated and hand packaging of wheat flour in preprinted plastic bags would cost approximately Tk 2 per 2 kg bag or Tk 1 per kilogram.

The proposed change from the distribution of wheat grain to that of fortified flour would result in a transfer of much of the wheat milling from *chakki* mills to roller mills. A few, large roller mills are much better able to produce, fortify, package and distribute flour, than could many, small *chakki* mills. Micronutrient addition at the hundreds of *chakki* mills that would be needed to supply this program is not really feasible. While it might be possible to have a number of *chakki* mills supply atta to a nearby batch fortification facility, if there was a strong political reason to do so, from practical, economic and nutritional viewpoints it would be better to have all the flour produced by roller mills.

The assessment team visited six roller mills and met with two roller-milling associations in order to assess the feasibility of producing fortified atta flour at such facilities. Normally, in counties with cereal fortification programs, only white flour (*maida*) is enriched or fortified with vitamins and minerals because it has a low micronutrient content and is the main flour staple. In this project, however, atta is to be produced and fortified. This presents two technical challenges. The first is to produce enough prepackaged fortified atta from roller mills to supply the FFE program, and the second is to introduce fortification technology to Bangladesh.

If 12 kg of atta were substituted for 15 kg wheat in the FFE program, the total amount of atta required would be 240,000 MT/year or 658 MT/day. If there were a need to have fortification/packaging centers or mills located in all 64 districts, each would have to produce about 10 MT per day. A 100 MT/day capacity roller mill should be able to produce 10 MT/day of fortified, packaged atta without design modifications. Smaller mills would either have to combine atta production or include more maida into the atta to achieve that amount. On the other hand, some 100 MT/day mills could be specially set up with respouting to produce up to 50 MT/day atta, and these could supply a number of districts or a heavily populated district.

Regarding the question of milling technology, the assessment team saw no evidence and received no reports of flour mills fortifying flour or adding any type of improver to flour. There were reports by some millers that their competition must be bleaching flour, but this could not be confirmed. The roller mills in Bangladesh, thus, have no experience with flour treatment, even though the maida standards do allow it. Section 2.1 states: "*Where deemed necessary by the miller, it* (maida) *may be treated with minute quantities of bleaching agents and improvers which are not harmful to health.*" There is no similar provision for atta. There were no ingredient feeders found in any of the mills visited, nor was there any convenient location for feeders to be installed. Ingredient feeders, when used, are generally located over the flour collecting conveyors in mills of the design and age of those observed. These conveyors in the Bangladesh mills were mostly located on the ceilings, making it difficult if not impossible to place a feeder directly above it. In the smaller roller mills, the atta stream did not normally go through a conveyor, making it even more difficult to fortify.

There are two ways flour can be fortified: continuous process or batch process. For continuous processes, used in most flour mills, the fortification premix is metered into the flour as it flows through a conveyor or pneumatic transfer spout. This involves a small capital expense for the *feeder* and associated equipment. Batch processes use a batch flour mixer, which is simple in practice but requires a higher capital investment. Continuous fortification requires there be some point in the mill where the flour to be fortified flows through a tube or conveyor in sufficient quantity and at a fairly constant rate. It also requires some level of mixing after the point of addition. Unfortunately, these criteria cannot be met with atta production in most of the roller mills in Bangladesh.

Many of the roller mills in Bangladesh have a wheat milling capacity around 48±20 MT/day. This size mill would produce 1.6 MT of flour per hour. If 15% of that flour was atta, it could produce only 240 kg of atta per hour. A premix designed to be added at a rate of 1kg/MT would have to be metered in at a rate of 240 g/hr or 4 g/min. This is the low end of a premix addition rate that can be reliably controlled. It is in these cases that wheat atta would have to be pooled, fortified, and mixed in batch mixing facilities.

Two of the mills visited (Noorani in Dhaka and Fouji in Chittagong) had automated packaging equipment that could be used to fill 2 kg bags. The government mill filled bags by hand. All were heat sealed, preprinted plastic bags. A white opaque bag, as used by one company, would probably be preferred to help protect the fortified product from light for greater vitamin retention. The estimated cost of the package and packaging, whether done by machine or by hand, is Tk 2 per package or Tk 1 per kg.

B. Proposed Wheat Atta Fortification Plan

1. Types and levels of micronutrients to add

Given the nutritional needs in the Bangladesh, the team proposes the following premix formula to be evaluated. The premix would add the following nutrient levels to the wheat atta: 100 parts per million (ppm) iron in the form of ferrous fumarate, 50 ppm zinc in the form of zinc oxide, 4 ppm riboflavin, 2 ppm folic acid and 10,000 IU per kilogram of vitamin A in the form of SD250, protected vitamin A palmitate.

The team further recommends that in order to enhance iron absorption, 300 ppm of disodium EDTA be added and that the ash content of the atta be specified as having a maximum of 0.7 percent. Also, consideration should be given to adding other selected B vitamins to atta with this ash specification.

Providing flour to the recipients of the FFE program allows the opportunity to fortify that flour with certain micronutrients that are recognized as being deficient within the target population. Which nutrients should be added and at what levels depends on three factors: (1) how seriously they are in deficit, (2) the technical problems associated with their addition to flour, and (3) their cost.

In discussing food fortification with various NGOs, universities and public health officials, there appeared to be general consensus that any fortification program should address the problem of iron deficiency anemia, which is recognized as being a serious nutritional

problem throughout the country. There was also strong but not unanimous support for including vitamin A. While there is a recognized vitamin A deficiency problem, there is also some concern about multiple and overlapping vitamin A intervention programs causing potential problems with some people getting excessive and unsafe amounts. One solution to this situation is to include vitamin A at a low enough addition level to ensure safety in case of overlapping programs. There was also support for including folic acid, zinc and riboflavin. Vitamin C was the only other micronutrient in which there was interest expressed. Unfortunately, vitamin C in the forms currently approved for addition to foods would not survive the chapati baking process so there is no point in adding it to atta. It would be possible to include some other vitamins and minerals if there was sufficient interest.

Iron fortification of atta and *chapatis* presents a special problem due to the inhibition of iron absorption by phytic acid, found to be at high levels in atta samples as shown in Table 4. Specification of a flour with an ash content below 0.7% would help ameliorate this problem and appears to be possible based on the atta samples collected.

Another approach is to use iron-EDTA (ethylenediaminetetraacetate)[2] or to add disodium EDTA along with iron, the later approach being somewhat less expensive. Disodium EDTA should be added with iron in a 0.5:1.0 molar ratio for optimum enhancement of iron absorption, if tests show that the phytic acid content in the atta chapatis is high enough to warrant its use. Along with testing phytic acid levels in chapatis made with atta, research consideration should also be given to the possible use of the enzyme *phytase* to reduce or eliminate the phytic acid in the chapatis.

Planners must also confirm the type of iron to be added. Ferrous sulfate or ferrous fumarate are better from a nutritional viewpoint, but their effect on the quality, taste, odor, and acceptance of the atta need to be studied. Coating the iron salts could prevent adverse reaction, but this would increase the cost of fortification. Reduced iron has been used as a low cost alternative when others have proven unacceptable, but is it the less desirable option from a nutritional point of view. Consequently, some tests must be done to see what form of iron is the most nutritionally effective and acceptable. Some testing of atta is currently being done in India and Pakistan, and results from those studies could contribute to this project.

Each added nutrient should be high enough to produce a significant beneficial effect at the levels of atta normally consumed by the recipients, while not being a high risk at the maximum probable consumption of atta. Also, the added level of micronutrients should not be so high as to cause adverse effects on organoleptic properties or general acceptance of the fortified food during its expected shelf life. The addition levels for the five nutrients proposed in Table 6 appear to meet these criteria, but they must be subjected to further evaluation and testing.

We suggest that the fortification project start with the forms and levels of the two minerals and three vitamins shown in Table 6 for purposes of determining costs, stability in chapatis

[2] The disodium salt of EDTA (ethylenediaminetetraacetate) is used as a food additive in a wide range of foodstuffs in the U.S. and many other countries. The JECFA (Joint Expert Committee on Food Additives) of the Codex Alimentarius recommended its approval for use in 1974. In 1993 and 1999 the JECFA reviewed sodium iron EDTA and considered it to be safe in food fortification programs. Iron EDTA is currently used in Kellogg's cereals marketed in Latin America

and effects on atta and *chapati* quality, appearance, taste and acceptance. Lab tests should be done using three types of iron with and without EDTA. A revised fortification proposal incorporating the results of those tests would then be formally reviewed by nutritionists, health authorities and other stakeholders in Bangladesh who may request changes in the types, forms and addition levels of the micronutrients to be added prior to the pilot program. The results of the pilot after review will determine the fortification to use in the full implementation.

Table 6. Proposed atta fortification

Nutrient	Form	Add mg/100g	% in premix for 1 kg/MT addition
Iron	Ferrous fumarate	10	10
EDTA	Disodium EDTA	30	30
Zinc	Zinc oxide	5	5
Vitamin B2	Riboflavin	0.4	0.4
Folacin	Folic acid	0.2	0.2
Vitamin A	SD250 Palmitate	1000 IU/100g	10

The above formulation attempts to uniquely suit the needs of the people of Bangladesh, rather than match standards being used in other countries. However, the proposed atta fortification levels are consistent with levels that are being proposed for other developing countries or that have been added to food aid commodities for decades. For example, the level of iron being proposed is 10 mg/100 grams. U.S./Canadian standards are only 3.73 mg, however, the levels being proposed for wheat in the Northern African region and in South Africa are 6 mg/100 grams. The World Food Program standard is 8 mg/100 g. for blended cereals. Wheat Soy Blend (WSB) and Corn Soy Blend (CSB), two U.S. food aid commodities, have been iron fortified for over 30 years. WSB and CSB are fortified at not less than 14.7 mg /100 grams in the form of ferrous fumarate, the same form of iron being proposed here. Each year these foods are consumed by millions of people in developing countries, the largest amounts are consumed by mothers and children in Indian's Integrated Child Development Services (ICDS) program. Another ICDS cereal food, Indiamix, specifically designed for India by the World Food Program, has 13 mg of iron/100 grams.

The other levels being proposed are also in keeping with common practice. The levels of vitamin A fortification being proposed for atta (1000 IU/100 grams) is less than one half of the level in all processed cereals, including wheat flour, used in U.S. PL 480 food assistance programs and two-thirds the level used by the World Food Program in Indiamix. The riboflavin and folic acid levels are nearly the same at the U.S./Canadian domestic standard, new standards now being proposed for other developing countries, and the level used in food assistance processed cereals. The level of zinc (5 mg/100 grams) compares well with the new level of zinc in food aid commodities established by the United States Department of Agriculture in January 1998.

Alternative fortifications options

If wheat atta with an ash content below 0.7% is specified for use in the FFE program, it would provide less B vitamins than that obtained from the *chakki* milled whole wheat atta

now being consumed under the program. It may then be necessary to replace these lost vitamins, or even add additional amounts to ensure adequate intakes, as provided in the supplementary B vitamin fortification shown in the following table. The additional cost of adding these four B vitamins would be $0.80 per MT of atta, or Tk 0.04 per kg of atta, increasing the cost by 10%.

Table 7: Micronutrients added under Alternative Fortifications

Nutrient	Supplementary B vitamins *mg/100g*	US/Canadian Standard mg/100g
Vitamin B1 (Thiamin)	0.5	0.58
Vitamin B2 (Riboflavin)		0.4
Vitamin B6	0.5	
Vitamin B12	0.001	
Folic acid		0.15
Niacin	5	4.6
Iron		3.75

One other alternative is to add to wheat atta the same flour enrichment premix being used in the United States, Canada and some other developed countries. The types and levels of micronutrients added under this option are shown in the above table. The cost of adding this standard premix with reduced iron is $1.11 per MT of atta, or Tk 0.055 per kg of atta. Use of this premix would not require testing of effect on atta quality or consumer acceptability because it is used routinely in similar flours with no problems. However, as discussed above, it does not address the nutritional needs of Bangladesh, particularly for iron and vitamin A.

In light of the large and persistent problem of iodine deficiency, it might also be desirable to add sodium iodate. The cost of including enough potassium iodate to supply one-third of a school child's recommended daily intake, would cost an additional Tk 1.0 per metric ton of atta. That would increase the cost of the premix, negligibly, by about one-quarter of a percent.

2. Atta fortification premix production and technical assistance

The team found that the vitamin/mineral premix required to fortify flour could be made in Bangladesh, but recommends that the initial quantity needed for the pilot program be acquired from an established premix company until local production capability is demonstrated. It would cost about Tk 0.4-.5 to fortify one kilogram of atta using the proposed fortification with Sodium EDTA.

A flour fortification program for the Bangladesh FFE program will require:

1. *Fortification premixes, made from quality ingredients, properly blended, assayed and packaged. The premix could be imported for the initial pilot but should eventually be manufactured within the country.*
2. *Equipment needed to fortify atta, either in a roller mill or in a dedicated mixing operation.*

3. *Technical assistance on the design and construction of fortification facilities, on how to properly fortify flour, and on the quality control and operating procedures necessary to ensure correct fortification.*

Production of the premix: Investigations were made into the possibility of producing an atta fortification premix in Bangladesh. Two companies were contacted, Beximco Pharmaceuticals and Renata Ltd., to assess the capabilities and interest of Bangladesh companies to manufacture the premix. Both companies had modern laboratory facilities and the ability to analytically test for all the components. Renata is currently producing premixes for animal feeds, so they are already in a related business and expressed interest in entering this one. Beximco, is primarily a pharmaceutical company and expressed little interest in food fortification.

A fortification premix made according to Table 6 would cost roughly $8.00 per kg if made in the United States. 49% of this cost is for the sodium EDTA and 34% is for vitamin A. Shipping to Bangladesh would add $0.40 per kg giving a landed cost of $8.40/kg. There would doubtless be tariffs and other costs that would increase the price, but they are not included in these calculations. Since the premix is added at a rate of 1 kg per metric ton of flour, it would cost $8.40 per MT of flour or Tk 420/MT. We estimate that a local producer could supply this premix for around Tk 400/MT or Tk 0.4 per kg of atta. The total annual ingredient cost to fortify 240,000 MT of atta flour would be Tk 96 million or about two million dollars. This cost would be cut in half if the EDTA were not included.

Capital equipment requirements and costs: It should be possible to equip a roller mill with a feeder and associated equipment necessary to fortify atta for approximately $20,000 if imported from the U.S., or about half that if made locally. The equipment used in the Bangladesh roller mills was generally made locally based on a copied design. The cost for batch mixing facilities would be around $50,000 per plant, including equipment, shipping, and installation costs. We suggest that the pilot include several different designs using imported equipment, and where there would be no conflict with intellectual property rights, assist other Bangladeshi millers to procure, adapt, or model equipment at their own expense when they decide to participate in the expanded program. While the pilot equipment should be funded, little financial assistance for equipment may be required in the full program. This would be the investment cost to the mill or millers association to enter this business.

Technical assistance: Millers and milling associations will need help in establishing and maintaining their fortification capability. One or two Bangladeshis who have been trained in flour fortification, preferably in the United States and working initially under a technical consultant could do this. These technicians would help set up and run the pilot program. After that is completed they could help expand and monitor the program, working either for a commercial premix company or for other organization involved with the project. This person or persons would be critical in the success of both the pilot and full program since they be the main means of technology transfer and monitoring.

C. Potential Impact and Safety of Fortification

The consumption by a school age child of one and one-half chapatis (75 g) daily made with the fortified wheat atta will provide from 25 to 75 percent of the average child's recommended intake of the five critical micronutrients. If the average child consumes this

amount it will fill the gap between their daily intake and daily requirement of both iron and vitamin A.

Even at the highest, levels of wheat consumption probable, the micronutrient intake from the fortification will pose a negligible health risk to consumers.

The potential impact of the recommended micronutrient fortification levels on children in terms of supplying a percentage of the WHO recommended dietary intake (RDI) for children at different atta intakes is quite favorable (Table 8). A 90% vitamin A retention is used in these calculations as observed in a previous study by the University of Dhaka. Also calculated is the number of *chapatis* that represents the different atta intake levels, using 50 grams of atta per *chapati*. The amount of micronutrients supplied by these addition levels at the target intake of 75 grams of atta per day or three chapatis ranges from 25% to 75% of the RDI.

The last column in Table 8 relates to the safety question of these added levels. Daily consumption of five *chapatis* per day would not result in any risk of overdose. A consumption of 10 *chapatis* per day could result in quite high intakes of iron and vitamin A, but such high consumption is nearly impossible because of children's low energy requirements and low intakes relative to needs. Furthermore the amount of projected intake would be comparable to amounts routinely given daily in a iron or vitamin A supplemental tablet. Even at the 10 *chapati* level, the iron consumption would be well below the United Kingdom's recently established maximums for safe upper limits of child consumption. With regard to vitamin A and iron, it needs to be noted that there are no documented cases of toxic overdose from consumption of foods fortified with these nutrients. One may go lower on the iron addition, but certainly no higher based on these calculations because of iron's potential for causing atta and *chapati* quality problems. The other nutrients are also well within acceptable limits.

Table 8. Nutritional Impact of Proposed Fortification at Different Intake Levels

flour consumption (g/day)	25	50	75	100	250
chapati equivalent (no./day)	0.5	1	1.5	2	5
	Percent of average child's recommended intake				
Vitamin A (IU)	19%	38%	56%	75%	188%
Riboflavin (mg)	8%	17%	25%	33%	83%
Folic Acid (mg)	20%	40%	60%	80%	200%
Iron (mg)	25%	50%	75%	100%	250%
Zinc (mg)	13%	25%	38%	50%	125%

D. Quality Control and Quality Assurance

An effective program of atta fortification will require careful attention to the control and legal assurance of the levels of premix composition and micronutrient content in the final product.

Quality control involves proper operational procedures at processing plants, inventory audits of premix usage by plants, and periodic testing of product samples by a capable

laboratory. As an added measure of verification, schools could be educated to test for the presence of fortification in wheat atta. In view of the recent changes in distribution process, dealers who distribute wheat to the schools, could also be educated to test for the presence of fortification in wheat atta.

As fortification becomes a full-scale program, quality assurance measures are required for the legal regulation of fortified atta by the Ministry of Industry or other authorities, e.g., the Ministry of Health and Family Welfare. This will require changes in legislation, publication of a standard for fortified atta, and licensing of producers. For routine product monitoring, the government may arrange for a capable independent laboratory with appropriate, modern equipment to conduct the monitoring.

In its salt iodization effort Bangladesh has learned that simply installing appropriate fortification equipment does not ensure that fortification will be done and done correctly. Consequently, from the onset the atta fortification project must establish a system to ensure that the product meets quality standards. This assessment recommends four quality control procedures need to be taken:

1. Mills producing the product must be assisted in establishing procedures and training personnel in the operation and maintenance of feeders, such as the coordination of feeder rates with the milling rates to ensure proper amounts of premix are added uniformly to the product.

2. Mills and micronutrient premix suppliers must collaborate in trouble shooting operational problems and premix suppliers must maintain inventories to ensure that the premix is being procured and used at the proper rates.

3. Appropriate laboratories must be identified to monitor micronutrients in samples of fortified atta from the mills. Test results should be available quickly to all stakeholders: the mills, the premix manufacturers, and the project management. If necessary, operating equipment and operational procedures should be adjusted to achieve proper fortification levels. (Potential laboratories with modern equipment, such as a high performance liquid chromatograph (HPLC), are those at the Institute of Nutrition and Food Science at the University of Dhaka and the International Center for Diarrheal Disease Research-Bangladesh.)

4. To more fully involve all stakeholders in the process, develop test kits for school and consumers at large to verify for the presence of the fortificant in wheat flours. The iron presence test, widely used to test for iron in fortified PL480 wheat flour, could easily be adapted for this purpose. Involving the public in this way would encourage manufacturers to produce a quality product. These kits would also be available to atta producers and to dealers at FFE distribution centers. The Institute of Food Science and Technology has developed similar kits for testing for the presence of iodine in salt. They could be requested to develop a similar test kit for atta.

In addition to quality control procedures, institutional steps should be taken to assure consumers that fortified wheat atta meets recognized legal standards. As a first step legislation will be required to modify language in the Pure Food Ordinance to allow fortification of wheat flours. This process will require the involvement of the Ministry of

Health and Family Welfare, the Ministry of Food, and the Ministry of Industry. In addition, a standard of identity and labeling of fortified wheat atta should be established and published by the Ministry of Industry's Bangladesh Standards and Testing Institution (BSTI). Plants producing fortified wheat atta would subsequently be licensed to produce according to the standard and would submit samples periodically to BSTI for license renewal.

Accomplishing this level of assurance may eventually require either an up-grade of the existing laboratories at BSTI or another government laboratory, such as the one housed at the Ministry of Food. For the first few years, however, we recommend that testing be done by capable existing laboratories based on a memorandum of understanding with the Ministry of Industry or other regulating authorities. FFE project management should continue its quality control procedures, outlined previously, until regulatory mechanisms became established and reliable.

E. Costs and Financing

The annual added production cost for wheat atta processing, fortification, and packing for five FFE pilot districts is estimated to be in the range of $850,000 or Tk 42 million, and the estimated cost for the entire program would be $10.8 million or Tk 538 million. However, until the exact price being charged by millers is negotiated and the method of financing using the available wheat grain is decided, the net cost of the project cannot be projected with confidence.

The cost of fortification for five pilot sites is estimated to be $168,000 annually, and for the full project $2.2 million annually. USAID should pay for the fortification premix for during the pilot phase, estimated to be one year.

The pilot phase costs for capital equipment, food consumption and rapid assessment studies, product development studies, and training of one or two Bangladeshi in fortification technology in the U.S. is estimated to be from $220,000 to $270,000.

Because of the complexities and cost uncertainties of the program, we recommend the pilot phase be confined to five sites, and that USAID finance the supply of the premix for one year, leaving the milling and packing costs to be financed by the MOE.

Production Costs and Financing

This assessment confirms the unit production cost estimates made by previous assessments for added processing, packaging and fortification costs. Millers with automated packaging equipment provided an estimated cost for 2 kg packets at roughly Tk 2. The market price of unpacked atta was approximately Tk 12 per kg and the price of wheat grain approximately Tk 9-10 per kg. The fortification costs are estimated in the range of Tk 0.4-0.5 per kg. Therefore, the total added cost to produce fortified wheat atta is Tk 2.4 (~US$.05) per kilo or Tk 2400 per MT (US $48). If one includes the cost of the wheat the overall cost is composed of Tk 1.0 for wheat processing (8.3 percent), Tk 1.0 for packaging (8.3 percent) and Tk 0.4-0.5 (3.3 percent) for premix, and Tk9.5 for wheat (80 percent), yielding a total cost of just under Tk 12 per kg. However, depending on the margin for the miller, the project might pay from Tk 13 to Tk 16, judging from retail prices for packaged atta reported by the Department

of Agricultural Marketing and confirmed by our field visits in Dhaka, Chittagong, and Narayanganj.

Table 9 shows the atta production requirements for a modest pilot in five FFE district sites, for 10 sites and for all 64 districts including all 1.8 million FFE families who receive wheat, not rice. (These numbers are based on program figures for 1997-1998, the more recent year the program was unaffected by floods, see annex A.) We have assumed average sized FFE districts, and that families with one student in school will receive12 kg of atta per month in place of 15 kg of wheat grain, and families with more than one student will receive16 kg of atta in place of 20 kg of wheat grain, averaging about 12.3 kg of wheat atta per family. Thus the total monthly demand for wheat atta for all families would be 21,500 MT per district. Given a ten-month school year, this would amount to 215,000 MT/year, which would replace the entitlement of 270,000 MT of wheat grain.

Table 9 . Added Cost of Producing Packaged, Fortified Wheat Atta from Wheat Grain

Estimates	One District	Five Districts	Ten Districts	All Districts
MT/month	336	1,682	3,360	21,500
MT/year (10 months)	3,360	16,820	33,600	215,000
Tk/year (millions)	8.4	42.0	84.0	538
US$/year (millions)	0.17	0.84	1.68	10.75

The estimated added annual production cost for five districts is approximately US $850,000, for ten districts US$ 1.7 million, and for the nationwide program $10.8 million. The annual cost breakdown is estimated to be the following:

	Five Sites	**Ten Sites**	**All Sites**
Premix	$ 168,000	$ 336,000	$ 2,150,000
Milling and Packing	$ 672,800	$ 1,345,600	$ 8,600,000

However, the net cost of changing from wheat grain to fortified wheat atta depends on some factors we could not estimate with any confidence. We do not know how favorable a price agreement the Government will strike with the private millers and how, and at what price, the wheat grain now provided will be used to defray the cost to the GOB.

Below, we have described two possible financing options open to the MOF or MOE for procuring wheat atta using the wheat grain designated for the program:

Option 1: The MOE would simply buy the atta from mills at a wholesale price. This purchase would be financed in part from the sale of donated or imported wheat grain by the MOF on the open market. The amount of wheat grain sold would be equivalent to the wheat grain designated for the districts in question. A variation of this option would be to sell the donated wheat to mills designated for producing the atta for the program, and buy back the packaged and fortified atta from them. For the five-site pilot, sales of the wheat for an average sized district could raise roughly $4.5-5.0 million annually, depending on the market price of wheat. This approach was not favored by millers, but might offer certain contract

advantages to the Ministry of Education, e.g. payments could easily be withheld if wheat atta shipments were delayed or inferior in quality.

Option 2: Mills would be paid in kind for the atta by retaining a portion of the wheat supplied to them by the MOF. The MOF would provide millers wheat grain equal in value to the cost of the required fortified wheat atta. By that calculation the schools would receive about 0.8 ton of packaged atta for every ton of wheat given to the millers. If the ration is being reduced by 20 percent, the wheat presently available could roughly cover the atta costs, especially if the premix was financed by USAID. This option also has variations. For example, a portion of the wheat or a cash commission could be provided to the millers upon delivery of the wheat atta. This option was favored by the millers and the Minister of Food, who were quite familiar with arrangements that would involve milling wheat provided from the Ministry of Food while retaining a portion to cover their costs, a common practice for previous ration programs.

Capital Costs and Studies and Training Costs

Capital equipment necessary to supply fortified wheat atta in the pilot program will involve ingredient feeders and other plant modifications for three large modern roller mills (production of over 100 metric tons per day) and two batch mixing facilities for fortifying, mixing, and packaging wheat atta supplied from surrounding mills

USAID should equip each of the pilot mills and blending facilities with well-designed, modern equipment from U.S. manufacturing companies. The feeder equipment and installation will cost in the range of $60,000 each and the batch mixing facilities and installation will cost in the range of $100,000 each. Where there would be no conflict with intellectual property rights, assistance should be given to Bangladeshi millers to procure, adapt, or model equipment at their own expense when they decide to participate in the expanded program.

External funding is also required for the FFE consumption survey, the rapid attitude assessment, and the atta product development studies discussed previously. The budget requirement for these is estimated to be in the range of $30,000 to $50,000 for the survey and rapid assessment and $20,000 to $25,000 for the product development studies.

Funding should also be provided for technical assistance and training to Bangladesh during all three phases of the project, on the techniques of flour fortification, equipment design and installation, quality control, and other techniques. During the first phase, train in the United States one or two technologists from Bangladesh who are to provide assistance at milling and fortification facilities. The inclusive cost for training of one or two technologists is estimated to be in the range of $ 20,000-$40,000.

In summary the costs for capital equipment, studies, and training are the following:

Feeders for 3 Roller Mills	$ 60,000
Two Batch Mixing Facilities	$100,000
Consumption and Attitude Studies	$ 25,000--$50,000

Product Development Studies	$ 15,000--$20,000
Training of Technologist(s)	$ 20,000--$40.000
TOTAL	$220,000--$270,000

We must emphasize that these estimates do not include all the costs that will be involved in the pilot phase. They do not include any external technical assistance that might be required from USAID cooperating agencies or others. The estimates also exclude costs of project management, on-going quality control, and local training. Development of an accurate and comprehensive budget for the project should be completed early in the planning phase.

IV. RECOMMENDATIONS

The team recommends that USAID/Dhaka undertake the following actions:

1. Actively pursue a three-phase process for implementing the wheat atta fortification proposal, as follows: (1) a planning phase, (2) a pilot phase in five FFE district sites, and (3) an expansion phase into all FFE districts. The estimated time frame for implementation of the three-phase process is 36 months, approximately one year for each phase.

2. Expand and accelerate the effort to inform key local officials of the benefits and safety to the low income FFE family of micronutrient fortified wheat atta, and secure a waiver from the Ministry of Industry or other relevant authority to produce the fortified atta on a limited basis.

3. Secure a financing agreement between the MOE, MOF, and the private millers that includes a price millers will charge for the fortified atta and how the available wheat resource will be used, either by direct distribution to millers or through sales.

4. Fund technical assistance and training to Bangladesh during all three phases of the project, on the techniques of flour fortification, equipment design and installation, quality control, and other techniques. Begin by sending to the United States one or two Bangladeshi technologists for training in milling and fortification. As the project progresses, enlist the assistance of premix manufacturers (international and local) to work with millers on fortification technologies.

5. Conduct separate focus group interviews with samples of recipient households and schoolteachers to assess attitudes toward this proposed change in the ration during the planning phase. The interviews should assess the consequences for the FFE program objectives and households' food security. Similar inquiries should also be made with FFE grain distribution dealers. These results should be used to adjust the ration size and means of distribution. In any case, FFE students must not receive not less than of 12 kg of fortified atta monthly for one student households and 16 kg monthly for households with two or more students in place of the present wheat grain ration.

6. Commission a rapid survey during the planning phase to determine the actual levels of wheat consumption by households and how FFE food rations are allocated between household members. Make projections to confirm and quantify the assumption that there is a greater propensity for households to consume wheat atta than wheat grain. Ration size and fortification levels for effective and safe nutritional impact must be adjusted according to the results of these inquiries. This survey should begin to lay the groundwork for cost effectiveness studies to be done during the pilot phase that will measure how efficiently the project reaches poor households with nutritional benefits. If possible, to save time and cost, perform these actions together with recommendation number five.

7. Evaluate a premix formula that would add to wheat atta the following four nutrient levels: 100 parts per million (ppm) iron in the form of ferrous fumarate, 50 ppm zinc in the form of zinc oxide, 4 ppm riboflavin, 2 ppm folic acid, and 10,000 IU per kilogram of vitamin

A in the form of SD250 protected vitamin A palmitate. The team further recommends that in order to enhance iron absorption, 300 ppm of disodium EDTA be added and that the ash content of the atta be specified as having a maximum of 0.7 percent. Consideration should be given to adding additional B vitamins to atta with this ash specification, and the addition of sodium iodate should be considered.

8. Commission organoleptic studies to detect and eliminate any perceptible changes in the fortified atta that are disagreeable to future consumers, and commission stability studies to determine the retention of vitamin A in fortified atta and chapatis prepared from it. Conduct these studies of the proposed fortification at suitable laboratories, one in the U.S. and one in Bangladesh. When the results are available, convene a meeting of stakeholders, professionals and authorities in Bangladesh to review and approve the fortification system(s) to be adopted for the pilot phase of the program.

9. Provide premix samples and specifications to Bangladeshi manufacturers who presently produce vitamin/mineral premix products for the animal feed industry, and request that they produce a high quality product at reasonable cost. Import the premix until Bangladeshi producers demonstrate their capacity to do so.

10. In cooperation with the MOE, select five FFE school districts for the pilot phase that are reasonably representative of the whole program. Include at least two districts from outside of the Dhaka division. Use fortification operations and facilities in these districts as models for other districts as the project goes to scale.

11. Fund the cost of needed equipment and the premix for pilot phase operations, including the following: (1) installation of ingredient feeders, and other necessary modifications, for three large modern roller mills (production of over 100 metric tons per day) for producing atta flour required by FFE program within three pilot districts, and (2) the installation of a batch mixing facility for fortifying, mixing, and packaging wheat atta within two pilot districts. Equip the pilot mills and blending facilities with well-designed, appropriate, modern equipment from U.S. manufacturing companies. Where there would be no conflict with intellectual property rights, assist other Bangladeshi millers to procure, adapt, model equipment at their own expense when they decide to participate in the expanded program.

12. Arrange for the supply of unfortified wheat atta to batch mixing facilities from smaller roller mills in two pilot districts where batch facilities are located. Approach millers' associations for this purpose.

13. Implement three quality control procedures: (1) regular atta production reporting and inventory audits of premix purchases; (2) analytical testing of products for marker nutrients, particularly vitamin A, by capable local laboratories, and (3) development and employment of "iron spot" test kits for verifying fortification at FFE schools, atta production facilities and at FFE ration distribution centers.

14. Contract with a capable laboratory in Bangladesh for routine wheat atta micronutrient testing during the planning and pilot phase of the project.

15. Provide assistance to the Bangladesh Standards and Testing Institution. (BSTI) to establish and publish a fortified wheat atta standard.

16. Assist the Ministry of Industry and/or other regulating agency to develop a memorandum of understanding with an existing capable laboratory in Bangladesh for long term quality assurance testing and producer licensing. Equipping a government laboratory with the necessary analytical equipment is not recommended at this time.

17. At the end of the pilot phase, conduct a review of all results so that the implementation phase may be entered into smoothly.

18. From the outset, establish a project team with the capability to deal with all aspects of the project, including the food security and nutrition issues, economics and financing, and institutional relationships. The team should be adroit at advising the GOB on the cost effectiveness of the project for meeting the country's priority social problems. As appropriate, make use of the technical assistance of the MOST project for assistance in technical management, and use the SUSTAIN project to assist in training, testing, product development and initiation of the pilot.

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VII. ANNEX A: PROGRESS OF THE FOOD FOR EDUCATION PROGRAM

Table 1: Allocation and Expenditure of Funds (In Lakh Taka)

Year	Allocation	Expenditure	Percentage of Allocation
1993-94	6,938	6,832	98.46%
1994-95	19,376	19,346	99.84%
1995-96	26,906	26,749	99.42%
1996-97	33,000	32,953	99.86%
1997-98	37,500	37,498	99.99%
1998-99	39,543	39,542	99.99%
Total	163,263	162,921	99.79%

Table 2: Number of Participating Institutions and Students

Financial Year	Union	Primary Institutions	Enrolled Student	Beneficiary Student		Benificiary Family		
				N	%	One Child Family	More Child Family	Total
1993-94	460	4,914	1,504,437	706,519	46.96	395,640	154,241	549,88
1994-95	1,000	12,182	3,619,243	1,628,659	45.00	1,172,634	244,298	1,416,93
1995-96	1,243	16,159	4,960,813	2,239,805	45.15	1,685,187	277,309	1,962,49
1996-97	1,243	17,203	5,719,590	2,280,467	39.87	2,052,974	121,529	2,174,50
1997-98	1,243	17,403	5,739,890	2,295,956	40.00	2,060,284	121,931	2,182,21
1998-99	1,247	16,117	4,512,760	1,692,245	37.50	1,590,325	45,935	1,636,26

Note that in 1995/6 there where

78,595	Schools	20.56	% Schools Covered
17,580,000	Students	28.22	% of students in covered schools

Table 3: Quantity and Value of the Subsidies

Financial Year	Quantity of Distributed Food				Value of transfer per family per annum	
	Wheat	Rice	Total	In Lakh Taka	One Child	More Child
1993-94	79,337	216	79,553	6,506	Tk 1,471	Tk 2,941
1994-95	168,462	6,024	174,486	18,682	Tk 1,807	Tk 2,410
1995-96	237,273	3,897	241,170	25,726	Tk 1,899	Tk 2,532
1996-97	67,760	209,625	277,385	31,798	Tk 2,030	Tk 2,707
1997-98	269,624	71,039	340,663	36,130	Tk 2,095	Tk 2,794
1998-99	227,026	59,636	286,662	38,185	Tk 1,863	Tk 2,485

Source: Tables Compiled by IFPRI/FMRSP

VIII. ANNEX B: SCOPE OF WORK

BANGLADESH WHEAT FORTIFICATION FEASIBILITY ASSESSMENT (11/99)

[Purpose

The purpose of this assessment is to determine the feasibility of producing micronutrient fortified wheat atta (flour) in Bangladesh and introducing it into the Food for Education (FFE) program.]

Dates

December 5-17, 1999

Team

Three persons with extensive experience in fortification, nutrition, milling and food assistance.

Peter Ranum, Grain Milling Expert with SUSTAIN. Peter Ranum is a highly respected professional in food technology circles in the U.S. and international organizations. Ranum served as the lead researcher and project designer for the groundbreaking Micronutrient Assessment Project, which was implemented under a cooperative agreement between USAID and SUSTAIN.

Thomas Marchione, Nutrition Advisor for the Bureau for Humanitarian Response in USAID and program backstop for the Office of Food for Peace. Dr. Marchione managed the Micronutrient Assessment Project.

Samuel Kahn, Nutritional Biochemist and Senior Health-Nutrition Advisor for the Office of Health and Nutrition in the Global Bureau of USAID. Dr. Kahn manages the overall Project SUSTAIN cooperative agreement. Dr. Kahn plans to join the team during its final week in Bangladesh.

Objectives and Information Requirements

The team will investigate and offer recommendations in the following nine areas. For each of the areas, the team has identified information necessary to fully meet the objective.

1. **The fortification levels**. Determination of the levels and ranges of nutrient fortification in the milled flour, based on the nutrient needs in Bangladesh and the stability, quality control testing and bioavailability of alternative fortificants.

   Information required:
   - Local professional judgments on the country's priority micronutrient deficiency problems.

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- An analysis of the dietary intake of atta flour in the recipient population (means and maximum intake levels).
- Estimates of the total intake of micronutrients from fortification, regular diet, and supplementation programs in the recipient population, e.g. particularly vitamin A.
- Factors in the Bangladeshi diet potentially inhibiting iron and zinc absorption.
- Degree to which the processes can assure reliable and safe levels of micronutrients in the final product.

2. **The fortification premix**. Specification of the composition of the vitamins and minerals in the premix, including cost, quality specifications, and commercial availability.

   Information required:
   - Bioavailability of possible foritificants in the premix.
   - Comparative costs and quality of various premix formulations, and their availability locally and elsewhere.
   - Stability of alternative forms of the proposed vitamins in light of losses in milling, storage time after milling, and preparation of atta flour into chapatis or other foods.

3. **Milling technology**. Determination of technological improvements, if needed, in current milling facilities to provide a fortified product of acceptable quality, including equipment, process procedures, and personnel training at the facility level.

   Information required:
   - Observations of the operations of large and small milling facilities that are typical of the those envisioned in the full-scale FFE program.
   - Identification of the current equipment and new equipment required to introduce fortification and its incremental cost to purchase and install in various types of mills.
   - Skill levels of plant workers who will be operating milling and fortification equipment at various types of mills.
   - Milling processes and testing procedures used for insuring a quality flour.
   - Estimated recurrent cost of atta flour over bulk wheat of equivalent nutritional value.

4. **Self-life testing**. Assessment of the need for pre-testing the proposed product in a laboratory to determine the stability of added nutrients and physical properties affecting its acceptability (taste, smell, and appearance) after anticipated periods of storage and handling.

   Information required:
   - The shelf life of atta flour and chapatis or other products made from it.

- Capabilities of existing food technology laboratories for testing the shelf life of processed foods.

5. **Packaging**. Determination of possible packaging technologies, package size, material and labeling information.

   Information required:
   - Local judgment on the most desirable packaging technologies, i.e., hand packing or use of packaging equipment.
   - Availability of packaging equipment in local mills..
   - Costs to procure and install packaging equipment.
   - Estimated recurrent cost of packaging.
   - Desired level of product identification and promotion for labeling the bags of flour.

6. **Quality control technology**. An assessment of the laboratory requirements for periodic quality control testing by the Bureau of Standards and Testing Institute in Bangladesh.

   Information required:
   - Current quality control testing of foods at government laboratories.
   - Suitability of equipment for testing and assuring micronutrient levels.
   - Equipment needs, if any, and costs of equipment.
   - Current level of training of persons operating equipment and identification of training needs.

7. **Quality control monitoring**. Assessment of the institutional requirements for specifying, sampling, testing, and enforcing the levels of fortificants in the final product.

   Information required:
   - Current regulatory environment for the food industry.
   - Present procedures for monitoring and enforcing the quality of processed food products.
   - Likely organization in government for instituting quality monitoring and enforcement.

8. **Site selection**. Identification of possible criteria for selection of the 8-10 initial project sites to maximize chances of successful scale up.

   Information required:
   - Observations of typical mills with various production capacities in different localities.
   - Observations of government and private milling facilities. .
   - Geographical local of mills and FFE distribution points.

9. **Next steps**. Suggested on-going steps to fully detail, follow-up and implement the recommendations flowing from objectives 1-8.

Approach

Key Informant Interviews: Meetings with USAID/EGAD and PHN mission teams, and the most appropriate Bangladeshi Government and private milling industry representatives will be made. This must include, at minimum, key persons in the Ministry of Food, the Ministry of Education, BSTI, and FMRSP/IFPRI, MI, HKI, World Bank, and others.

Site Visits: Site visits will include a representative sample of potential milling facilities, preferably during operating hours. These visits are critical to the assessment and must include the range of plant capacities and sophistication, which may eventually be used in the full-scale program. Site visits to analytical laboratories that are candidates for product testing should also be made.

Document Reviews: Documents on nutrition and food security in Bangladesh, the FFE program, and the food industry are being gathered by the team. (see references).

A full itinerary and documentation will be completed with the assistance of USAID/Dhaka.

Reporting and Follow-up

The team will conduct a briefing of its preliminary results before departing Bangladesh in December, and it will provide a completed report by the early part of February 2000.