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# MICRONUTRIENT FORTIFICATION AND ENRICHMENT OF P.L. 480 TITLE II COMMODITIES: RECOMMENDATIONS FOR IMPROVEMENT

TECHNICAL REVIEW PAPER

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This technical review paper "Micronutrient Fortification and Enrichment of P.L. 480 Title II Commodities: Recommendations for Improvement" was prepared by the Opportunities for Micronutrient Interventions (OMNI) project. The OMNI project was developed and funded by the U.S. Agency for International Development's Office of Health and Nutrition, Bureau for Global Programs to assist in the global effort to reduce micronutrient deficiencies in developing countries. The OMNI project which is managed by John Snow, Inc. consists of members from Helen Keller International, Emory University School of Public Health, The Manoff Group, John Hopkins University, International Life Sciences Institute Human Nutrition Institute, Program for Appropriate Technology in Health, University of Arkansas, and University of California, Davis.

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TECHNICAL REVIEW PAPER

**Micronutrient Fortification and Enrichment of P.L. 480 Title II Commodities: Recommendations for Improvement**

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## EXECUTIVE SUMMARY

This report has been prepared in response to a request from USAID's Bureau for Humanitarian Response (BHR) to examine the various options for micronutrient fortification of the USAID food aid commodities. There is increasing global attention to reduce malnutrition caused by deficiencies in essential vitamins and minerals, commonly referred to as micronutrients. Micronutrient malnutrition is a serious public health problem in many developing countries and has significant direct and indirect consequences on economic and social development. The P.L. 480 program offers a unique opportunity to reach the most vulnerable groups -- children, women of reproductive age, and displaced persons and refugees -- with essential micronutrients.

This report, prepared by the Opportunities for Micronutrient Interventions (OMNI) project provides technical information about past and current enrichment and fortification practices, quality assurance of the fortified commodities, product and fortificant stability, and appropriate and safe levels of fortification.

Based on analyses of current fortification practices, knowledge of micronutrient requirements, and technological developments, several recommendations are presented to improve the micronutrient content of P.L. 480 Title II commodities. Although most of the recommendations are straightforward, further evaluation will be needed to outline detailed procedures for implementation.

### Use of P.L. 480 Commodities

In 1993, the United States Government provided 7.78 million metric tons (MT) of food assistance valued at $2.28 billion through its P.L. 480 programs. These programs, implemented through host-country governments, private voluntary organizations (PVOs), cooperating development organizations (CDOs), and international agencies, have distributed food to over 90 countries. Under the Title II program, approximately 1.9 million MT were distributed to 68 countries with a cost of about $510 million.

In 1993, approximately 47 percent of Title II commodity funds were spent on emergency programs and 53 percent on regular programs. In the regular program, USAID Title II commodities are intended as food supplements that are targeted to the most nutritionally vulnerable groups[1]. Commodities are provided for direct consumption through Maternal and Child Health (MCH) and school feeding (SF) programs, other child and preschool feeding programs, general relief programs, and for indirect consumption through food-for-work (FFW), or monetization programs.

Fortification of food for displaced people and refugees was endorsed at the 1992 International Conference on Nutrition, with 159 countries adopting the World Plan of Action which included the recommendation that *"donor countries and involved organizations must therefore ensure that the nutrient content of food used for emergency food aid meets nutritional requirements, if necessary through fortification and supplementation."*

[1] Beneficiaries are generally those at greatest risk of micronutrient deficiencies and include the very poor, pregnant and lactating women, young children, and displaced persons and refugees.

## Fortification and Enrichment of P.L. 480 Commodities

Since 1966, USAID and USDA have routinely fortified or enriched Title II foods in order to prevent micronutrient deficiencies among P.L. 480 recipients. The Food for Freedom Act (1966) linked food aid to country development efforts and placed greater emphasis on the use of food commodities as nutritional supplements, especially for young children, pregnant, and lactating mothers.

Title II commodities include two blended food supplements - corn soy blend (CSB) and wheat soy blend (WSB) as well as processed cereals - wheat flour, cornmeal, bulgur, soy-fortified bulgur, soy-fortified cornmeal, soy-fortified sorghum grits, and instant corn soy masa flour. CSB and WSB are fortified with "vitamin and mineral premixes" containing eleven vitamins, (A, B-12, C, D, E, folic acid, niacin, pantothenic acid, pyridoxine, riboflavin, and thiamin) and six minerals (calcium, iodine, iron, phosphorus, sodium, and zinc), while the processed cereals and soy-fortified cereals are enriched with an "enrichment ingredient" containing the B vitamins, vitamin A, iron, and calcium. Wheat flour is fortified with vitamin A and calcium but not with iron and the B vitamins. Vegetable oils, pulses, rice, and whole grains are not fortified or enriched with micronutrients.

The 1993 total expenditure on fortification and enrichment ingredients was estimated at $15.064 million. The cost of micronutrients added to processed and soy-fortified cereals is less than 2.5 percent of the value of the product, while that for blended foods is less than 5 percent of the value of the product.

## Fortification Considerations

Key issues for most micronutrient fortification initiatives include determination of appropriate types and levels of fortificants, the bioavailability (solubility, absorption, and utilization) of the fortificants, and the stability of the micronutrients in fortified foods. These issues were reviewed in the context of the Title II program mandate.

Particular attention was given to the types and levels of iron since there are several different iron fortificants which vary in their bioavailability and their interaction with other food components.

The food commodity used to deliver the micronutrients was also examined. For example, vegetable oils and whole grains are not currently fortified, although technologies are available to elevate their micronutrient content.

Studies were reviewed that had examined the stability of micronutrients in P.L. 480 Title II commodities. Most micronutrients were determined to be adequately stable depending on moisture levels.

Efforts to assess stability of micronutrient levels, however, are seriously hampered by the lack of quality control prior to shipment from the United States. Future field assessments or estimations of impact on recipients will be similarly hampered until planned and specified levels of micronutrients in commodities can be assured within known limits when commodities are shipped.

## Micronutrient Contribution of P.L. 480 Title II Commodities

A large share of the P.L. 480 Title II program targets the young child and the pregnant woman as well as displaced persons and refugees for supplementary feeding and general ration distributions. The micronutrients in commodities were evaluated in regard to the micronutrient requirements of these two groups of recipients. Assumptions were made about the amount of individual commodities consumed by these recipients since definitive data are not available.

**The young child and the pregnant woman:** Using the current fortification levels, calculations were made to illustrate potential micronutrient intake of the young child and the pregnant woman who are the primary recipients of fortified blended foods. Given that Title II foods are designed to be used as a *supplement* to the locally available diet, contributing about 25 percent of total dietary energy requirements, most vitamin and mineral requirements for preschool and pregnant women would be met, with a few exceptions from a cereal-based (rice, sorghum, cornmeal, or wheat) diet supplemented with vegetable oil and CSB.

Deficiencies of iron, riboflavin, and zinc were identified in these diets. In contrast, levels of calcium, phosphorous, vitamin B-12, and folic acid were calculated to be greater than the required allowances. Calcium and phosphorous in the blended fortified foods are supplied by tricalcium phosphate, an ingredient which aids in controlling moisture.

Vitamin B-12 levels are excessive in all diets due to high fortification levels established from earlier dietary allowances which have since been reduced. Although folic acid levels exceed estimated needs in all diets for both the young child and pregnant women, the current level is important to maintain since folic acid needs increase before and during pregnancy.

**Displaced persons and refugees:** The commodities distributed to this group include whole grains, oil, pulses, and to a lesser extent, processed cereals. Calculations made to estimate the micronutrient content of rations in relation to Recommended Dietary Allowances (RDAs) for an adult male indicated that the adequacy of micronutrient intake depends on the cereal being used, and in general, diets are deficient in several vitamins and minerals, especially calcium, iron, vitamin C, vitamin B-12, and riboflavin.

## Recommendations

Based on reviews of current practice and the known benefits of micronutrients, the following recommendations are proposed given management feasibility to improve the micronutrient content of P.L. 480 Title II commodities. Recommendations for specific micronutrients are to increase, decrease or maintain current levels or to change to an improved compound. Recommendations directly related to micronutrient levels and associated cost implications and implementation feasibility are summarized in Table A.

Also included are recommendations for monitoring, evaluation, quality assurance, and research to further improve the micronutrient content of P.L. 480 food commodities. The costs for these general improvements have not been determined.

The following recommendations are classified according to apparent ease of implementation (Table A). Those which have no apparent technical or managerial constraints to implementation are identified as "short-term." Those which will have additional research contingencies or require minor managerial consultation with other stakeholders are identified as "medium-term." Those that will require more comprehensive research, negotiations and dialogue with a wide range of stakeholders (e.g., USDA, industry, cooperating sponsors, the World Food Program, and USAID bureaus and missions) are marked as "long-term."

## I. Short Term: No Apparent Research Requirements or Managerial Constraints

### A. Improvements of Micronutrient Content in Blended Food Supplements

1. Reduce Vitamin B-12 Levels by Approximately Two-thirds, 67.5 Percent.
Since the formulation for the blended food supplements was made, the RDA for vitamin B-12 has been reduced. Reducing the amount of vitamin B-12 from 4.0 to 1.3mcg/100g would satisfy the requirements for one to three year old children and pregnant women.

2. Increase Riboflavin Levels by 114 Percent.
Riboflavin in the blended foods should be more than doubled to provide the requirements of the target populations. Populations subsisting on rice- or corn-based diets supplemented with blended foods are especially deficient in riboflavin.

3. Increase the Amount of Zinc Ten-fold and Change the Type of Compound Being Used. Rice and corn-based diets supplemented with blended foods are currently very low in zinc. A ten-fold increase is recommended to provide adequate allowances. Also, zinc sulfate monohydrate should be considered as an alternative to zinc sulfate heptahydrate since it is more stable and less expensive.

4. Maintain Current Vitamin C Levels.
Until further information becomes available on the stability of vitamin C during storage and preparation, current levels should be maintained.

### B. Improvements of Micronutrient Content in Processed Cereal Commodities

1. Wheat Flour Should be Enriched with Iron, Niacin, Thiamin, and Riboflavin
Wheat flour is currently enriched with calcium and vitamin A. It is recommended that wheat flour for P.L. 480 Title II programs be enriched with levels of iron and the B vitamins similar to the amounts used in enriched flour marketed in the U.S.

2. Use Ferrous Fumarate Instead of Hydrogen Reduced Iron.
It is recommended that 5mg of iron from ferrous fumarate be used per 100g of processed cereal in place of hydrogen reduced iron. This will provide more absorbable iron than would be provided by doubling the amount of hydrogen reduced iron.

### C. Whole Grains and Milled Rice Should Not be Enriched or Fortified

Although procedures have been developed to enhance the micronutrient content of whole grains and milled rice, delivery of micronutrients by these commodities has several disadvantages and difficulties, as well as a substantial cost.

### D. Strengthen USAID Technical Participation in and Oversight of Fortification and Enrichment Practices

Participation as needed of agriculture, food technology, and nutrition representatives on the USAID Committee on Nutrition Specifications of Food Aid Commodities is essential for providing current technical information and direction to assist with improving the nutritional quality of P.L. 480 Title II commodities.

## II. Medium Term: Additional Research Requirements and Minor Managerial Constraints

### A. Improvements of Micronutrient Content in Blended Food Supplements

1. Increase Ferrous Fumarate by 50 Percent if Stability, Odor and Taste Tests are Positive. Increasing the iron supplied by ferrous fumarate from 15mg to 22.5mg/100g of blended food supplements would provide 97 and 58 percent of the RDA for one to three year old children and pregnant women, respectively.

2. Reduce the Amount of Tricalcium Phosphate by 25 Percent, If Studies Confirm that Nutritional, Anti-caking and Insect Suppressant Properties of TCP Can be Retained. The blended food supplements currently contain a concentration of two percent tricalcium phosphate (TCP) which provides an excessive amount of calcium and phosphorous. A 25 percent reduction in TCP will still provide adequate nutrients and it should not affect the other functions provided by TCP (anti-caking and insect suppression).

### B. Promote Use of Fortified Blended Food Supplements in Emergency Situations

Agencies should be encouraged to use presently available blended and/or enriched commodities along with locally available foods to provide limited nutrients.

### C. Establish Quality Control Program for Ensuring Micronutrient Content of P.L. 480 Title II Commodities Prior to Shipment

Currently, quality and quantity of micronutrients added to P.L. 480 Title II commodities are not monitored. A quality assurance program should be implemented to evaluate the amount of certain micronutrients in the fortified and enriched foods prior to shipment.

### D. Promote Development of International Standards for Micronutrient Fortification and Enrichment Practices

There are large differences in micronutrient fortification and enrichment practices between countries providing food aid. Without uniformity in micronutrient levels of foods, the dietary requirements of recipients are difficult to satisfy. An Expert Panel convened by FAO/WHO could assist with developing uniform International Standards for micronutrients in food aid commodities.

### E. Establish a Mechanism to Investigate Micronutrient Problems at the Field Level

A mechanism is needed to obtain information on the actual needs, stability, and consumption of micronutrients in P.L. 480 Title II commodities. A system to continually obtain useful information about micronutrients through adaptive research should be developed. Agency resources should be allocated to assist with accomplishing research required for developing improvements to the food commodities in the PL 480 program.

## III. Long Term: Comprehensive Research Requirements and Major Managerial Changes

### A. Improvements of Micronutrient Content in Blended Food Supplements

Reduce Moisture Content to a Maximum of 8.5 Percent. Low moisture content of foods retards losses in the micronutrients, spoilage from molds and insects, and adverse changes in flavor and color. The ability and cost of maintaining lower moisture content, especially of blended food supplements, should be evaluated.

### B. Fortify Vegetable Oil with Vitamin A

Vegetable oil is an excellent vehicle for delivering vitamin A to target populations. Associated with this recommendation is the requirement for tailoring fortification of commodities for specific Title II programs. Fortification of vegetable oil would not be beneficial for all programs and, when fortified vegetable oil is provided, vitamin A does not need to be included in the blended foods.

### C. Consider Local Fortification and Enrichment in Special Circumstances under Carefully Controlled Conditions

Whole grains can be shipped to recipient countries where they would be milled and fortified or enriched with micronutrients.

### D. Target Delivery of Commodities According to Nutritional Needs

More explicit guidance needs to be provided on regional programming of commodities.

## Table A:
## Summary of Estimated Costs of Recommended Changes in Micronutrient Content of P.L. 480 Title II Commodities and The Additional Research and Management Requirements for Implementation

| Recommendations | Current Costs of Micronutrients ($/MT) | Cost Increase or Decrease ($/MT) | Cost Increase or Decrease Based on 1993 Tonnage (million $) | Potential Implementation Time Based on: Additional Technical Information/ Research Required | Potential Implementation Time Based on: Degree of Management Constraints/ Difficulties |
|---|---|---|---|---|---|
| **Blended Food Supplements** | | | | | |
| Increase ferrous fumarate by 50% (from 0.46kg to 0.69kg/MT) | 1.29 | +0.65 | +0.20 | Medium | Short |
| Reduce vitamin B-12 by 67.5% (from 40mg to 13mg/MT) | 0 40 | -0.27 | -0.09 | Short | Short |
| Increase riboflavin by 114% (from 3.9g to 8.2g/MT) | 0.27 | +0.36 | +0.09 | Short | Short |
| Increase zinc ten-fold and use monohydrate instead of heptahydrate form of zinc sulfate | 0.16 | +0.94 | +0.30 | Short | Short |
| Reduce tricalcium phosphate (TCP) by 25% (from 20kg to 15kg/MT) | 30.00 | -7.50 | -2.40 | Medium | Medium |
| Reduce moisture content from about 10% to 8.5% | – | +0 83 | +0.25 | Long | Long |
| Maintain current vitamin C fortification level | 6.62 | 0 | 0 | Short | Short |
| **Vegetable Oil** | | | | | |
| Fortify vegetable oil with vitamin A (from 0 to 150 million IU/MT) | 0 | +7.80 | +1.06(a) (+0.53)(b) (a) Vitamin A is not added to oil for monetized program or (b) Corn soy blend of Integrated Child Development Programs | Long | Long |
| **Processed Cereals, Excluding Rice** | | | | | |
| Enrich milled wheat flour with iron, niacin, thiamine, and riboflavin | 0 | +0 72 | +0.19 | Short | Short |
| Use ferrous fumarate instead of hydrogen reduced iron (excludes use of ferrous fumarate in wheat flour) | 0.07 | +0 17 | +0.09 | Short | Short |
| **Whole Grains and Milled Rice** | | | | | |
| Whole grains and milled rice should not be enriched or fortified | 0 | 0 | 0 | Short | Short |

| Table A Cont.<br>General Program Activities (Cost estimates are unavailable) | Potential Implementation Time Based on: | |
|---|---|---|
| | Additional Technical Information/ Research Required | Degree of Management Constraints/ Difficulties |
| Promote use of blended food commodities for emergency programs | Short | Medium |
| Establish quality control programs for enriched/fortified foods | Medium | Medium |
| Strengthen technical participation/ oversight for enrichment/fortification practices | Short | Short |
| Promote development of international standards | Medium | Medium |
| Establish mechanism to investigate micronutrient problems at field level | Medium | Medium |
| Target delivery of commodities according to nutritional needs | Medium | Long |
| Develop local fortification/ enrichment for special circumstances | Long | Long |

## LIST OF ABBREVIATIONS

| | |
|---|---|
| ACC | Administrative Committee on Coordination |
| AMS | Agricultural Marketing Service |
| ASCS | Agricultural Stabilization and Conservation Service |
| BHA | Butylated hydroxy anisole |
| BHR | Bureau for Humanitarian Response (USAID) |
| BHT | Butylated hydroxy toluene |
| CARE | Cooperative for American Relief Everywhere |
| CCC | Commodity Credit Corporation |
| CDC | Centers for Disease Control |
| CSB | Corn Soy Blend |
| CSM | Corn Soy Milk |
| DHHS | Department of Health and Human Services |
| EDTA | Ethylenediaminetetraacetic acid |
| FAO | Food and Agriculture Organization |
| FDA | Food and Drug Administration |
| FFW | Food-for-Work Program |
| FGIS | Federal Grain Inspection Services |
| g | gram |
| GRAS | Generally Recognized as Safe |
| ICCIDD | International Council for the Control of Iodine Deficiency Disorders |
| ICDS | Integrated Child Development Services |
| IDD | Iodine Deficiency Disorders |
| INACG | International Nutritional Anemia Consultative Group |
| IU | International Unit |
| JECFA | FAO/WHO Joint Expert Committee on Food Additives |
| kg | kilogram |
| MCH | Maternal and Child Health |
| mcg | microgram |
| mg | milligram |

| | |
|---|---|
| MT | Metric Ton (2204.6 pounds) |
| NaFeEDTA | Sodium Iron Ethylenediaminetetraacetic acid |
| NAS | National Academy of Sciences |
| NIH | National Institutes of Health |
| NRC | National Research Council |
| OMNI | Opportunities for Micronutrient Interventions |
| P.L. 480 | Public Law 480 |
| PVO | Private Voluntary Organization |
| RDA | Recommended Dietary Allowance |
| SCN | Subcommittee on Nutrition |
| SFCM | Soy-Fortified Corn Meal |
| SF | School feeding |
| T | Ton (2,000 pounds) |
| TCP | Tricalcium Phosphate |
| USAID | United States Agency for International Development |
| USDA | United States Department of Agriculture |
| WHO | World Health Organization |
| WFP | World Food Program |
| WSB | Wheat Soy Blend |

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# I. INTRODUCTION

## A. Background

In 1993, the United States Government provided 7.78 million metric tons (MT) of food assistance valued at $2.28 billion through Public Law 480 (P.L. 480) programs. These programs, implemented through both the US Agency for International Development (USAID) and US Department of Agriculture (USDA) and working with host-country governments, private voluntary organizations (PVOs), and international agencies have distributed food to over 90 countries (USAID/BHR, 1993a). The majority of P.L. 480 recipients are among the most nutritionally vulnerable and include the very poor, pregnant and lactating women, young children, and displaced people and refugees. These populations are particularly at risk of micronutrient deficiencies.

Dietary deficiencies of protein and energy, especially among preschool children and pregnant and lactating women, are almost always accompanied with multiple deficiencies of essential vitamins and minerals that are required in small amounts. Hence, they are known as micronutrients. In countries where populations subsist on a monotonous diet of cereals and other grain-based foods, deficiencies of vitamin A and iron can be widespread.

Micronutrient deficiencies are a widespread public health concern, although prevalence of specific deficiencies can vary considerably both within and between countries. Deficiencies of vitamin A, iodine, and iron are especially important because of their serious health consequences and wide geographic distribution (FAO/WHO, 1992a).

Globally, the most prevalent micronutrient deficiencies are lack of iron, which affects over 2000 million people; lack of iodine, which affects over 1000 million people, and insufficient vitamin A, which affects over 190 million people (Table 1.1). Iodine deficiency disorders (IDD) are particularly a problem in non-coastal mountainous areas where iodine has been leached from the soil. Vitamin A deficiency occurs in areas where fruit and vegetable consumption and sometimes fat intake are low. Iron deficiency is largely due to poor absorption of dietary iron although intestinal parasites and malaria can predispose people to anemia.

Other micronutrient deficiencies, such as zinc, selenium, folic acid, and other micronutrients can affect large numbers of people. Outbreaks of deficiency diseases - beriberi (thiamin deficiency), pellagra (niacin deficiency), and scurvy (vitamin C deficiency) occur among refugees and other displaced populations (Toole, 1993). Without adequate riboflavin, growth is retarded in children, and adults lack the ability to expend energy efficiently; clinical lesions, anemia, and neurological dysfunction may also result from riboflavin deficiencies (Combs, 1992). Zinc deficiency results in retarded growth (dwarfism) and impaired sexual development (hypogonadism) especially in young boys, immunological abnormalities, skin changes, and developmental disorders in pregnancy (NRC, 1989).

Micronutrient levels in diets can be improved by enriching or fortifying foods which are widely consumed on both a regular basis and irregular amounts by the target population. In the enrichment of a food, such as wheat flour, some of the micronutrients, such as iron, niacin, and thiamine, removed in the milling process are restored to approximate original levels. Nonfat dry milk is enriched when the fat-

soluble vitamins A and D, removed with the milk fat, are restored to the levels originally in whole milk. In contrast, fortification of a processed or formula food, involves the addition of nutrients at higher levels than are normally present in the natural food substances.

**Table 1.1:**
**Populations at Risk or Affected by Iodine, Vitamin A, and Iron Deficiencies by Region**

| Region (a) | Iodine deficient | | Vitamin A deficient (b) | | Iron-deficient or anemic |
|---|---|---|---|---|---|
| | At risk | Affected (goiter) | At risk | Affected (xerophthalmia) | |
| | (millions) | | (millions) | | (millions) |
| Africa | 150 | 39 | 18 | 1.3 | 206 |
| Americas | 55 | 30 | 2 | 0.1 | 94 |
| Southeast Asia | 280 | 100 | 138 | 10.0 | 616 |
| Europe | 82 | 14 | – | – | 27 |
| Eastern Mediterranean | 33 | 12 | 13 | 1.0 | 149 |
| Western Pacific (c) | 405 | 30 | 19 | 1.4 | 1058 |
| Total | 1005 | 225 | 190 | 13.8 | 2150 |

Source: FAO/WHO 1992a
(a) WHO regions.
(b) Pre-school children only.
(c) Includes China

In view of the necessity to maximize the benefits of the limited resources aimed at improving nutrition, USAID/BHR requested that a technical review be conducted on the current status of fortification and enrichment of P.L. 480 Title II commodities, highlighting issues of concern and identifying options and recommendations for improvement. Under the auspices of the USAID Office of Nutrition, the OMNI Project (Opportunities for Micronutrient Interventions) was requested to conduct this review (Appendix A details the Scope of Work)

This paper reviews the current status of enrichment and fortification practices used in the P.L. 480 Title II program. Discussion focuses on documenting the nutrients added to particular commodities and considerations for altering current fortification and enrichment practices to help meet specific nutritional needs. Attention is given to concerns raised recently in regard to the need and safety of proposed increased fortification and enrichment levels of iron. A number of options to improve the program as well as their associated costs are proposed based on review of available reports, documented information, and communications with relevant resource persons (Appendix B lists Persons Consulted) Finally, suggestions for further research and information on program recipients to support the enrichment and fortification program for P.L. 480 Title II commodities are provided.

## B. History of Fortification and Enrichment of USAID P.L. 480 Commodities

The original authority for the foreign donation program was granted in the Agricultural Act of 1949. This was amended through Public Law 480 in 1954. In the early years, the main foods distributed were whole grains, flour, nonfat dry milk, and soybean and cotton seed oils. Early in 1965, vitamins A and D were added to nonfat-dried milk because it was the only donated food suitable for meeting the supplemental nutrition needs of infants and preschool children.

Late in 1965, USAID, USDA, and National Institutes for Health (NIH) cooperatively devised guidelines for the composition of formula foods, which could serve as supplements in the diets of children or in emergency feeding for adults. The original purchase of a supplementary food mixture for children contained gelatinized corn meal, soy flour, nonfat dry milk, vitamin and mineral mixes, and 10 percent wheat flour that could be formed into the shape of a cereal grain, if desired (Combs, 1967). Later, durum wheat was eliminated from the formula resulting in the corn-soy-milk (CSM) product. Vitamin C and soy oil were subsequently added after stability tests were conducted. In May 1966, CSM was tested through child feeding programs in India. From this and other trials, CSM was found to be an acceptable, bland, and safe product suitable as a supplement (supplying approximately 25 percent of total dietary energy) in the diets of young children.

Through the Food for Freedom Act of 1966, food aid was linked to country development efforts. The Act amended P.L. 480 by allowing the U.S. Government to pay for enriching, fortifying, and blending donated foods and a "second generation" of Title II food aid commodities were developed (Forman and Fellars, 1985). The Act placed greater emphasis on the use of food commodities as nutritional supplements, especially for young children, pregnant women, and lactating mothers. The Act also removed the stipulation that the commodity had to be an officially declared surplus to be eligible for donation abroad and it authorized the purchase of nutrient mixtures for nutritional improvement of foods.

The need to provide sufficient amounts of essential micronutrients in the early child food supplements was well understood, and foods were fortified with eleven vitamins and six minerals. In general, the levels of vitamins and minerals in 100g of CSM supply at least one-half the National Academy of Sciences - National Research Council (NAS-NRC) Recommended Dietary Allowances (RDA) for the one to three year old child. The exception is Vitamin B-12 which was added to provide 100 percent of the RDA at that time. By May 1967, 230 million pounds of CSM had been purchased for use in child and maternal feeding centers in some 90 different countries. The first purchase cost $0.21/kg ($0.09/lb), packaged in 22.7kg (50lb) bags delivered to ports, but later purchases were as low as $0.16/kg ($0.072/lb) (Senti, 1968). Subsequently, the vitamin and mineral premixes designed for CSM have been used in other similar food supplements.

In 1968, it was recognized that a wheat-based fortified food was needed for use among wheat-eating populations. Specifications were developed for a food containing wheat or bulgur flour, wheat protein concentrate, soy flour, soy oil, and the vitamin and mineral mixes used in CSM. In addition, specifications for a protein-fortified wheat flour that was also fortified with vitamin A and calcium were developed for use in bread-making.

In the late 1970s, the USA supply of nonfat dry milk was inadequate, and it was no longer feasible to include it in blended foods. For this reason, dried whey was substituted for nonfat dry milk. In recent years, it has been necessary to eliminate most milk-based products from blended food supplements because of their high cost and low availability. This change has had no adverse affect on the palatability of the blended products. Adjustments were made to maintain adequate nutrient levels following the elimination of milk products.

In 1988, vitamin A levels in blended food commodities were increased from 1100 international units (IU) to 2000IU/100g, based on recommendations of an expert panel convened by USAID. In 1990, the levels of iron and vitamin C added to various P.L. 480 processed commodities were reviewed by another expert panel convened by USAID. This panel recommended that the amount of fortified iron be doubled. However, this recommendation was not implemented due to a lack of consensus among reviewers on issues of safety and sensory acceptability of increased iron levels.

Presently all processed Title II commodities, except vegetable oils, pulses, whole grains, and rice are fortified or enriched with micronutrients. Three different vitamin and mineral premixes are used and are discussed in Section II.

The role of the P.L. 480 program in improving food security has received increasing attention by the development community. The Agricultural Development and Trade Act of 1990 states:

> *"It is the policy of the United States to use its abundant agricultural productivity to promote the foreign policy of the United States by enhancing the food security of the developing world through the use of agricultural commodities and local currencies accruing under the act to:*
>
> *1) Combat world hunger and malnutrition and their causes;*
> *2) Promote broad-based, equitable, and sustainable development, including agricultural development;*
> *3) Expand international trade;*
> *4) Develop and expand export markets for United States agricultural commodities; and*
> *5) Foster and encourage the development of private enterprises and democratic participation in developing countries."*

The purpose of the P.L. 480 program as stated in the Act is to promote food security. Food security is defined in the Act as "access by all people at all times to sufficient food and nutrition for a healthy and productive life." FAO estimates that perhaps as much as one-fifth of the world's population has too little food to permit healthy and productive lives (FAO/WHO, 1992a). During the 1980s, food assistance was treated less as relief and more as a resource for economic and social development, including food security.

USAID Title II food commodities are often intended to be used as supplements to the diet of nutritionally vulnerable target populations in order to improve the nutritional quality of the total diet. Commodities are provided for direct consumption through programs such as maternal and child health (MCH) and school feeding (SF), other child and preschool feeding programs and general relief programs or for indirect consumption through food-for-work (FFW) or monetization programs that increase the resources available to households for the purchase of additional and perhaps more nutritious foods. Directly or indirectly, food assistance programs aim to improve the resources of the very poor. Fortification and enrichment of foods with micronutrients improve the nutritional quality of diets which contribute to reduction of micronutrient malnutrition.

Poverty and lack of education are primary causes of hunger and malnutrition (FAO/WHO, 1992b). The complex interaction between social, political, cultural, and economic factors contributes to malnutrition. Prevention of disease and adequate maternal and child care practices, as well as access to food, are also needed to prevent malnutrition. It is important that food assistance programs recognize the need for sustainable development of agricultural production and related health and social programs to ensure that malnutrition in the long run, and indeed poverty itself, is ultimately reduced.

## II. CURRENT STATUS OF P.L. 480 TITLE II COMMODITIES

### A. Commodities Available Under the P.L. 480 Title II Program

Under the Title II program managed by USAID, the United States Government donates agricultural commodities to support emergency and non-emergency or regular food aid programs. These programs are co-administered by private voluntary organizations (PVOs), cooperative development organizations (CDOs), and by international relief agencies such as the World Food Program (WFP) through host countries. In addition, USAID co-administers Title II bilateral commitments with host governments for emergency response. In 1993, approximately 1,996,401MT were distributed through the Title II program to 68 countries around the world. Approximately 60 percent of the Title II tonnage was received by PVOs and CDOs for distribution in 38 countries. The remaining 40 percent was handled by BWFP in 60 countries. In terms of the total dollar value, approximately 47 percent was spent on emergency programs and 53 percent on regular programs (USAID/BHR, 1993b).

Each fiscal year, USDA determines the availability of a commodity based on the agricultural production and requirements in the USA. This is based on seasonal crop production surveys that determine USA domestic and emergency reserve requirements. USDA also details projections of staple food prices in order to safeguard domestic USA farm and consumer price levels. The Foreign Agriculture Service of USDA announces yearly the estimated prices of available commodities for P.L. 480 programs including those for the Title II program. The commodities available for Title II for FY 1994 are listed in Table 2.1 along with estimated prices. In general, whole grains are the least expensive commodities, followed by processed grains and soy-fortified processed grains. The blended foods are the most expensive grain-based items.

**Table 2.1: Estimated Prices of Title II Commodities for 1994**

| Commodity | Price ($/MT) |
|---|---|
| Wheat | 135 |
| Wheat flour | 203 |
| Bulgur | 184 |
| SF bulgur (a) | 190 |
| WSB (b) | 326 |
| Corn | 116 |
| Cornmeal | 203 |
| SF cornmeal | 233 |
| ICSM flour (c) | 250 |
| CSB (d) | 318 |
| Sorghum | 108 |
| SF sorghum grits | 208 |
| Veg. oil (e) | 885 |
| Veg. oil (f) | 797 |
| Veg. oil (bulk) | 593 |
| Rice | 450 |
| Peas | 235 |
| Beans | 800 |
| Lentils | 480 |

Source. Unpublished data, USAID December 1993
(a) SF - Soy Fortified
(b) WSB - Wheat Soy Blend
(c) ICSM, Instant Corn Soy Masa Flour
(d) CSB, Corn Soy Blend
(e) Vegetable oil in 1-5 gallon containers
(f) Vegetable oil in 55 gallon containers

## B. Uses, Quantities, and Values of Title II Commodities by Program Type

The Commodities Reference Guide (USAID/BHR, 1988) provides information to program planners on the type of available commodities and rations and the types of information needed to make decisions for commodity selection. Cooperating sponsors select commodities appropriate for programs in a given country. The regional use of Title II commodities is listed in Table 2.2 and the proportion of the value of the Title II foods going to different programs is provided in Table 2.3. In recent years, the value of Title II foods going to emergency programs has increased because of the increase of emergency programs in Africa, Europe, and the Near East. Changes in US food aid mirror similar changes in WFP food assistance (Nicholds, 1992; WFP, 1994).

**Table 2.2:**
**Distribution of Title II Commodities by Region in 1993 (Percentage of Total Quantity and Value)**

| Region | Quantity (percent of total) | Value (percent of total) |
|---|---|---|
| Europe | 9.9 | 10.8 |
| Near East | 2.4 | 3.0 |
| LAC (a) | 18.9 | 20.9 |
| Africa | 40.2 | 37.9 |
| Asia | 28.5 | 27.3 |
| Total % | 100.0 | 100.0 |
| Total MT ('000) | 1996.4 | -- |
| Total ($ million) | -- | 510.8 |

Source: Unpublished data, Food for Peace office.
(a) LAC - Latin America and Caribbean

**Table 2.3:**
**Distribution of P.L. 480 Title II Commodities by Region and by Program Type in 1993 (Percentage of Total Value)**

| Region | Program | | | | | | | | | TOTAL mil $ |
|---|---|---|---|---|---|---|---|---|---|---|
| | MCH | SF | FFW | OCF | OR | EMR | Other | MONET | TOTAL | |
| World | 23.6 | 7 0 | 12.5 | 3 0 | 2.8 | 42.5 | 0.0 | 8 7 | 100.0 | 510.8 |
| Africa | 6.9 | 6.5 | 4 4 | 0 7 | 3 6 | 66.3 | -- | 11.6 | 100.0 | 193 0 |
| Asia | 57.0 | 7 7 | 17 6 | 2.2 | 2 8 | 11 7 | -- | 1 0 | 100.0 | 139.0 |
| Europe | 0 0 | 0.0 | 0 0 | 0 0 | 0.0 | 96 5 | -- | 3 5 | 100 0 | 54.8 |
| Latin America | 22 4 | 9.8 | 27.7 | 9 7 | 9 7 | 9 4 | -- | 17.7 | 100 0 | 107 0 |
| Near East | 15.9 | 12.3 | 2.3 | 1.1 | 1.1 | 68 3 | -- | 0.0 | 100 0 | 15 3 |

urce Calculations based on unpublished data from Food for Peace Office
breviations MCH - Maternal and Child Health, SF - School Feeding, FFW - Food for Work, OCF - Other Child Feeding (including Preschool Child eding); OR - Other Regular, EMR - Emergency, and MONET - Monetized Programs

## Table 2.4:
## Distribution of P.L. 480 Commodities in 1993 by Type of Commodity (Percentage of Total Quantity and Value)

| Commodity | Percent of Total Quantity | | Percent of Total Value | |
|---|---|---|---|---|
| **Blends** | | 15.8 | | 16.2 |
| Corn-soy milk | 0.2 | | 0.2 | |
| Wheat-soy milk | 0.3 | | 0.6 | |
| Wheat-soy blend | 1.1 | | 1.8 | |
| Corn-soy blend | 14.2 | | 13.6 | |
| **Soy-fortified cereals** | | 4.5 | | 3.9 |
| SF bulgur (a) | 2.9 | | 2.9 | |
| SF cornmeal (a) | 0.7 | | 0.5 | |
| SF sorghum (a) | 0.5 | | 0.3 | |
| ICSM flour (b) | 0.3 | | 0.2 | |
| **Processed grains** | | 32.2 | | 29.8 |
| Rice | 10.8 | | 12.2 | |
| Bulgur | 5.5 | | 5.2 | |
| Cornmeal | 2.4 | | 1.7 | |
| Wheat flour | 13.5 | | 10.8 | |
| Rolled oats | 0.0 | | 0.0 | |
| **Vegetable oil** | | 8.7 | | 24.7 |
| **Whole grains** | | 32.8 | | 15.6 |
| Corn | 6.4 | | 2.3 | |
| Wheat | 22.7 | | 12.1 | |
| Sorghum | 3.6 | | 1.2 | |
| **Other** | | 6.5 | | 9.7 |
| Nonfat dried milk | 0.0 | | 0.0 | |
| Beans | 3.3 | | 5.9 | |
| Peas | 1.1 | | 0.9 | |
| Lentils | 0.2 | | 2.9 | |
| Total (%) | 100.0 | 100.0 | 100.0 | 100.0 |
| Total MT ('000) | 1996.4 | 1996.4 | – | – |
| Total ($ million) | – | | 510.8 | 510.8 |

Source Calculations based on unpublished data from Food for Peace Office
(a) SF - Soy Fortified
(b) ICSM - Instant Corn Soy Masa Flour

A detailed analysis of specific commodity quantity and value for 1993 shows that blended foods accounted for 16 percent of the value of shipments, soy-fortified cereals for 4 percent, processed grains for 30 percent, vegetable oil (a high value item) for 25 percent, whole grains for 10 percent, and other (mainly beans) 16 percent (Table 2.4). Thus, in 1993, fortified and enriched items accounted for 38 percent of the value, and non-fortified or non-enriched commodities accounted for 62 percent of the value of Title II shipments. A large portion of the value of non-fortified or non-enriched commodities is due to vegetable oil which accounts for about 25 percent of the total value but only 9 percent of the total metric tons of commodities distributed.

According to value of commodities distributed by program type, MCH programs received the greatest proportion of fortified blended foods and enriched soy-fortified products (Table 2.5). School feeding (SF) programs received the greatest proportion of allocations of enriched soy-fortified items. Emergency programs received the largest share of processed foods, whole grains, and oil. The only items monetized were oil, whole grains, and some processed grains (but not rice).

**Table 2.5:**
**Distribution of P.L. 480 Title II Commodities by Commodity and by Program Type in 1993 (Percentage of Total Value)**

| Commodity | MCH | SF | FFW | OCF | OR | EMR | MONET | TOTAL | Total Value (mil $) |
|---|---|---|---|---|---|---|---|---|---|
| | Percentage of Total Value | | | | | | | | |
| Blended foods | 64.0 | 5.6 | 5.9 | 2.5 | 3.6 | 18.5 | 0.0 | 100.0 | 83.0 |
| Soy-fortified | 28 7 | 31.7 | 14.1 | 3.5 | 0 3 | 21 6 | 0.0 | 100.0 | 19.9 |
| Processed | 12.3 | 6.2 | 15.4 | 65.8 | 5 4 | 50.3 | 4.5 | 100.0 | 152.2 |
| Whole grains | 13.2 | 6.0 | 15.6 | 0.0 | 2.8 | 44.6 | 17.9 | 100.0 | 79.7 |
| Oil | 19.8 | 3 4 | 13.4 | 2.8 | 1.2 | 38.1 | 21 4 | 100.0 | 126.2 |
| Other | 6.0 | 9 0 | 11.0 | 0.9 | 2.3 | 70 8 | 0 0 | 100.0 | 49.8 |
| Total | 22 7 | 6.6 | 12.9 | 3.1 | 3.1 | 42.2 | 9 4 | 100.0 | 510.8 |

Source· Calculations based on unpublished data from Food for Peace Office.
Abbreviations· MCH - Maternal and Child Health; SF - School Feeding; FFW - Food for Work, OCF - Other Child Feeding (including Preschool Child Feeding), OR - Other Regular; EMR - Emergency; MONET - Monetized programs.

The distribution of commodities by region on the basis of percentage of total value of each commodity is presented in Table 2.6. Asia received the largest proportion of blended foods, Latin America the largest proportion of soy-fortified foods, and Africa the largest share of processed grains, whole grains and oils as well as the largest share of other items (pulses). Although a distribution by country is not presented, it is important to note that the ICDS program in India received more than 50 percent of the total amount of blended foods.

**Table 2.6:**
**Distribution of P.L. 480 Title II Commodities by Region in 1993 (Percentage of Total Value)**

| Commodity | Region | | | | | Total | Total Value (mil $) |
|---|---|---|---|---|---|---|---|
| | Percentage of Total Value of Commodity | | | | | | |
| | Africa | Asia | Europe | Latin America | Near East | | |
| Blended foods | 24.7 | 57.9 | 0.2 | 17.5 | 0.0 | 100.0 | 83.0 |
| Soy-fortified cereals | 20.1 | 30.6 | 0.0 | 49.2 | 0.0 | 100.0 | 19.9 |
| Processed grains | 35.0 | 18.0 | 22.3 | 19.7 | 5.0 | 100.0 | 152.2 |
| Whole grains | 76.8 | 10.3 | 1.8 | 11.1 | 0.0 | 100.0 | 79.7 |
| Vegetable Oil | 36.9 | 23.5 | 8.6 | 24.3 | 6.6 | 100.0 | 126.2 |
| Other | 45.7 | 8.5 | 20.9 | 22.7 | 2.2 | 100.0 | 49.8 |
| Total | 37.8 | 27.2 | 10.7 | 20.9 | 3.3 | 100.0 | 510.8 |

Source Calculations based on unpublished data from Food for Peace Office.

## C. Current Fortification and Enrichment Practices

For Fiscal Year 1994, nine of the Title II food commodities available are fortified or enriched to some extent (Table 2.7). These include bulgur, cornmeal, wheat flour, soy-fortified bulgur, soy-fortified cornmeal, soy-fortified sorghum grits, instant corn soy masa flour, Wheat Soy Blend (WSB) and Corn Soy Blend (CSB). Current fortification and enrichment levels of selected P.L. 480 Title II commodities are achieved by adding a "vitamin premix", "mineral premix", or "enrichment ingredients" to given commodities as specified by USDA/ASCS.

The "vitamin premix" (Annex C) and "mineral premix" (Annex D) are added to the processed blended foods, WSB and CSB. Each premix is mixed with the blended food separately to avoid adverse chemical reactions between concentrated vitamins and minerals. The "vitamin mix" includes vitamins A, B-6 (pyridoxine), B-12, C (ascorbic acid), D, E (alpha tocopherol), thiamine, riboflavin, niacin, pantothenic acid, and folic acid. The "mineral mix" contains iron, zinc, calcium, phosphorus, sodium, and iodine as contained in iodized salt. The "enrichment ingredients" (Annex E) are added to most of the processed cereals including the soy-fortified cereals. These include cornmeal, bulgur, soy-fortified sorghum grits, soy-fortified cornmeal, soy-fortified bulgur, and instant corn soy masa flour.

## Table 2.7:
## Enriched and Fortified P.L. 480 Title II Commodities Shipped in 1993

| | Enrichment and Fortification Ingredients | | | | | |
|---|---|---|---|---|---|---|
| | Vit. A and Calcium | Vit. A and D | Vitamin Premix (a) | Mineral Premix (b) | Enrichment Ingredients (c) | Commodity Total (MT) |
| **Processed Blended Foods** | | | | | | |
| Corn soy milk (CSSM5) | -- | -- | x (d) | x | -- | 3892 |
| Instant corn soy milk | -- | -- | x | x | -- | 0 |
| Wheat soy milk (WSM5) | -- | -- | x | x | -- | 691 |
| Wheat soy blend (WSB9) | -- | -- | x | x | -- | 21728 |
| Corn soy blend (CSB6) | -- | -- | x | x | -- | 282739 |
| **Soy Fortified Cereal Foods** | | | | | | |
| Soy-fortified bulgur (BWSF4) | -- | -- | -- | -- | x | 57479 |
| Soy-fortified cornmeal (CMSF4) | -- | -- | -- | -- | x | 13861 |
| Soy-fortified sorghum grits (SFSG6) | -- | -- | -- | -- | x | 9262 |
| Soy-fortified wheat flour (WFSF4) | -- | -- | -- | -- | x | 0 |
| Soy-fortified rolled oats | -- | -- | -- | -- | -- | 0 |
| Instant corn soy masa flour (MF4) | -- | -- | -- | -- | x | 6123 |
| **Processed Foods - Other** | | | | | | |
| Rice | -- | -- | -- | -- | -- | 215765 |
| Bulgur | -- | -- | -- | -- | x | 109395 |
| Cornmeal | -- | -- | -- | -- | x | 48085 |
| Wheat flour | -- | -- | -- | -- | -- | 270003 |
| Rolled oats | -- | -- | -- | -- | -- | 0 |
| Vegetable oil | -- | -- | -- | -- | -- | 173360 |
| **Whole grains** | | | | | | |
| Corn | -- | -- | -- | -- | -- | 128478 |
| Wheat | -- | -- | -- | -- | -- | 452913 |
| Sorghum | -- | -- | -- | -- | -- | 72817 |
| **Dairy Products** | | | | | | |
| Nonfat dried milk (NFDM) | -- | x | -- | -- | -- | 38 |
| **Dried Beans/Peas** | | | | | | |
| Beans | -- | -- | -- | -- | -- | 65261 |
| Peas | -- | -- | -- | -- | -- | 22315 |
| Lentils | -- | -- | -- | -- | -- | 42298 |
| **TOTAL SHIPPED** | | | | | | **1,996,401** |

Source: USDA/ASCS Specifications - given in Announcements, February 1994, and commodity shipment data from USAID/BHR
(a) "Vitamin Premix" includes thiamine, riboflavin, vitamin C (ascorbic acid), pyridoxine, niacin, pantothenate, folic acid, vitamin B-12, vitamins A, D and E.
(b) "Mineral Mix" includes calcium, phosphate, zinc, iron, and iodine in iodized salt.
(c) "Enrichment ingredients" include vitamin A, iron, calcium, thiamine, niacin, and riboflavin
(d) x indicates the addition of the nutrients

Generally, enrichment refers to replacing those nutrients, thiamin, riboflavin, calcium, niacin, and iron, lost in the milling process. In addition to these nutrients, the "enrichment ingredients" specified by USDA/ASCS also contain vitamin A. According to the current USDA/ASCS specifications for wheat flour, only vitamin A and calcium are added, even though the B vitamins and iron are lost in the milling of wheat. Since the mid-1960s, the specifications for nonfat dry milk have included vitamins A and D, although nonfat dry milk is no longer included as a P.L. 480 Title II commodity.

To illustrate the level of micronutrients added per 100g of blended or processed foods, calculations were made based on the quantities added per 2000 pounds of final product given in USDA/ASCS specifications. Tables 2.8 and 2.9 list the vitamins and minerals, respectively, added to Title II commodities on a per 100g basis.

## D. Modifications Made to Fortification and Enrichment Practices

Relatively few changes have been made to the levels and type of fortificants used since fortification and enrichment practices for P.L. 480 commodities were designed nearly thirty years ago.

As mentioned, vitamin A levels added to blended and processed foods were increased in 1988 from 1100IU to 2000IU per 100g. Commodities fortified with vitamin A at this level include bulgur, cornmeal, wheat flour, soy-fortified bulgur, soy-fortified cornmeal, soy-fortified wheat flour, soy-fortified sorghum grits, and the blended foods including WSB and CSB. The current specifications for soy-fortified rolled oats do not include the addition of vitamin A, because this commodity has not been available since the specifications were made for adding vitamin A.

In the mid-1970s, calcium carbonate and dicalcium phosphate (DCP) were replaced with anhydrous tricalcium phosphate (TCP) as the source of calcium and phosphorus in the mineral premix added to blended foods. TCP was selected because of its reported anti-caking effect and its ability to suppress insect activity in stored cereal grain. More recently, USDA had proposed that TCP be replaced with a less expensive calcium and phosphorus source. USAID recommended to USDA that the use of TCP be continued unless other suitable sources of calcium and phosphorus could be identified that would provide similar nutritional, insect suppressant, and anti-caking qualities. The source of calcium is not specified by USDA/ASCS for enriching wheat flour, bulgur, and cornmeal. However, calcium sulfate, the inexpensive substance used for enriching wheat flour in the US, is the usual source of calcium.

After nonfat dry milk was no longer available, appropriate modifications were made to CSM and WSM to compensate for reduction in protein. This was done by increasing the soy content to develop two new products, namely corn soy blend (CSB) and wheat soy blend (WSB). In addition, a more stable ethyl cellulose-coated vitamin C was included in the specifications for CSB and WSB to enhance the absorption of iron from cereal-soy blended foods. The above modifications are the only substantive changes made to fortification and enrichment levels from those established nearly thirty years ago. However, several issues have been raised in regard to changing current practices, particularly in regard to iron (USAID, 1990), which are addressed in Section III. Related options and recommendations for modifying current fortification and enrichment practices are discussed in Section IV.

## Table 2.8:
## Vitamins Added to P.L. 480 Title II Commodities

| | Vitamins Added to 100g of Food | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Vit A (a) (IU) | Vit D (IU) | Alpha Tocopherol Acetate (mg) | Vit C (mg) | Thiamine Mononitrate (mg) | Riboflavin (mg) | Pyridoxine HCL (mg) | Niacin (mg) | Panto-thenate (mg) | Folic acid (mcg) | Vit B-12 (mcg) |
| **Processed Blended Foods** | | | | | | | | | | | |
| Wheat soy blend | 2314 | 198 | 7 5 | 40.1 | 0 28 | 0 39 | 0 165 | 5 9 | 2.75 | 198 | 3 97 |
| Corn soy blend | 2314 | 198 | 7 5 | 40.1 | 0 28 | 0.39 | 0 165 | 5 9 | 2.75 | 198 | 3 97 |
| **Soy Fortified Cereals** | | | | | | | | | | | |
| Soy-fortified bulgur | 2204-2645 | -- | -- | -- | 0 44-0 66 | 0.26-0.40 | -- | 3.5-5.3 | -- | -- | -- |
| Soy-fortified cornmeal | 2204-2645 | -- | -- | -- | 0 44-0 66 | 0.26-0 40 | -- | 3.5-5.3 | -- | -- | -- |
| Soy-fortified sorghum grits | 2204-2645 | -- | -- | -- | 0 44-0 66 | 0 26-0 40 | -- | 3 5-5 3 | -- | -- | -- |
| Soy-fortified wheat flour | 2204-2645 | -- | -- | -- | 0 44-0 66 | 0.26-0 40 | -- | 3 5-5 3 | -- | -- | -- |
| Instant corn soy masa flour | 2204-2645 | -- | -- | -- | 0 44-0 66 | 0.26-0.40 | -- | 3.5-5.3 | -- | -- | -- |
| **Processed Foods - Other** | | | | | | | | | | | |
| Bulgur | 2204-2645 | -- | -- | -- | 0 44-0 66 | 0.26-0.40 | -- | 3 5-5.3 | -- | -- | -- |
| Cornmeal | 2204-2645 | -- | -- | -- | 0 44-0 66 | 0.26-0.40 | -- | 3.5-5.3 | -- | -- | -- |
| Wheat flour (b) | 2204-2645 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Rolled oats | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Vegetable oil | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Nonfat dry milk | 5000-7000 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |

Source Calculations based on 1994 USDA/ASCS specifications for "vitamin mix," "mineral mix," and "enrichment ingredients "
(a) Vitamin A acetate is added to processed blended foods and nonfat dry milk. Vitamin A palmitate is added to soy-fortified cereals
(b) Note that wheat flour is not enriched with B-vitamins.

## Table 2.9:
## Minerals Added to P.L. 480 Title II Commodities

| | Minerals Added to 100g of Food | | | | | |
|---|---|---|---|---|---|---|
| | Calcium (mg) | Phosphorous (mg) | Iron (a) (mg) | Zinc (mg) | Iodine (mcg) | Sodium (mg) |
| **Processed Blended Foods** | | | | | | |
| Wheat soy blend | 744 | 400 | 15 2 | 0 9 | 45 5 | 254 |
| Corn soy blend | 744 | 400 | 15 2 | 0 9 | 45.5 | 254 |
| **Soy Fortified Cereals** | | | | | | |
| Soy-fortified bulgur | 110-165 | -- | 2 9-5 7 | -- | -- | -- |
| Soy fortified cornmeal | 110-165 | -- | 2 9-5.7 | -- | -- | -- |
| Soy-fortified sorghum grits | 110-165 | -- | 2 9-5 7 | -- | -- | -- |
| Soy-fortified wheat flour | 110-165 | -- | 2 9-5.7 | -- | -- | -- |
| Instant corn soy masa flour | 110-165 | -- | 2 9-5.7 | -- | -- | -- |
| **Processed Foods - Other** | | | | | | |
| Bulgur | 110-165 | -- | 2 9-5 7 | -- | -- | -- |
| Cornmeal | 110-165 | -- | 2 9-5 7 | -- | -- | -- |
| Wheat flour (b) | 110-165 | -- | -- | -- | -- | -- |
| Rolled oats | -- | -- | -- | -- | -- | -- |
| Vegetable oil | -- | -- | -- | -- | -- | -- |
| Nonfat dry milk | -- | -- | -- | -- | -- | -- |

Source Calculations based on 1994 USDA/ASCS specifications for "vitamin mix," "mineral mix," and "enrichment ingredients" added to commodities.
(a) Ferrous fumarate added to processed blended foods; Reduced iron added to soy-fortified cereals and other processed cereals listed.
(b) Note that wheat flour is not enriched with iron

## E. Current Costs of Fortification and Enrichment of Title II Commodities

The cost of enrichment and fortification of P.L. 480 Title II commodities is relatively low compared to the total value of the commodities (Tables 2.1, 2.10, and 2.11). For example, the ingredients for enriching processed and soy-fortified commodities costs less than 2.5 percent of the value of the processed foods and the ingredients for fortifying the more expensive blended food supplements costs less than five percent of their value. The costs required for blending, packaging, transport, storage, and handling of the enriched and fortified commodities have not been included in these cost estimates.

**Table 2.10:**
**Cost Estimates of Vitamins and Minerals Used for Enrichment and Fortification of Processed and Soy-Fortified Cereals**

| Processed Cereals (Excluding Wheat Flour and Rice) | | | | Total Costs of Ingredients Based on 1993 Tonnage (millions $) | |
|---|---|---|---|---|---|
| Vitamins and Minerals | Amount per 100g Food | Ingredient Cost $/kg | Estimated cost $/MT | Wheat Flour | Processed Cereals (Excluding Wheat Flour and Rice) |
| Thiamine | 0.44mg | 35.00 | 0.15 | 0.00 | 0.04 |
| Riboflavin | 0.26mg | 70.00 | 0.18 | 0.00 | 0.05 |
| Niacin | 3.5mg | 9.00 | 0.32 | 0.00 | 0.08 |
| Iron (reduced) | 2.9mg | 2.53 | 0.07 | 0.00 | 0.02 |
| Calcium | 110mg | 0.54 (a) | 0.60 | 0.16 | 0.15 |
| Vitamin A | 2204IU | 43 (b) | 3.79 | 1.02 | 0.94 |
| TOTAL | | | $ 5.11 (c) | $1.185 | $1.267 |

Source Watson Foods and Fortitech Inc.
(a) Based on $0 14/kg for calcium sulfate ($0.54/kg calcium)
(b) Based on 250,000IU/g
(c) Wheat flour contains only calcium and vitamin A ($4 39/MT)

**Table 2.11:**
**Cost Estimates of Vitamins and Minerals Used for Fortification of Blended Foods**

| Vitamins | Amount per 100g Food | Cost of Fortification $/kg | Estimated Cost $/MT | Total Costs of Ingredients Based on 1993 Tonnage (million $) |
|---|---|---|---|---|
| Vitamin A | 2314IU | 43 (a) | 3.98 | 1.255 |
| Vitamin D | 198IU | 12 (b) | 0.24 | 0.076 |
| Vitamin E | 7.5mg | 29 (c) | 4.35 | 1.371 |
| Vitamin C | 40.1mg | 16 | 6.62 | 2.087 |
| Thiamine | 0.28mg | 35 | 0.10 | 0.032 |
| Riboflavin | 0.39mg | 70 | 0.27 | 0.085 |
| Pyridoxine | 0.165mg | 50 | 0.08 | 0.025 |
| Niacin | 5.9mg | 9 | 0.53 | 0.167 |
| Pantothenate | 2.75mg | 24 | 0.66 | 0.208 |
| Folic acid | 198mcg | 125 | 0.25 | 0.079 |
| Vitamin B-12 | 3.97mcg | 110 (d) | 0.40 | 0.126 |
| Total for vitamins | | | 17.48 | 5.511 |
| Minerals | | | | |
| Calcium | 744mg | 1.50 (e) | 28.79 | 9.077 |
| Phosphorus | 400mg | (e) | | |
| Iron | 15.2mg | 2.80 (f) | 1.29 | 0.407 |
| Zinc | 0.9mg | 4.00 (g) | 0.16 | 0.050 |
| Iodine | 45mcg | | 0.06 (h) | 0.019 |
| Sodium | 250mg | | (h) | |
| Total for minerals | | | 30.30 | 9.553 |
| Total for minerals and vitamins | | | 47.78 | 15.064 |

Source: Watson Foods and Fortitech Inc
(a) Based on 250,000IU/g
(b) Based on 100,000IU/g
(c) 50 percent alpha tocopherol acetate powder
(d) One percent cyanocobalamin
(e) Tricalcium phosphate, 38.8 percent calcium; $5.87/kg calcium
(f) Ferrous fumarate, 33 percent iron
(g) Zinc sulfate, heptahydrate 23 percent zinc
(h) Iodized salt, 0 007 percent iodine

Enrichment of processed and soy-fortified cereals with the B-vitamins, iron, and calcium costs only $1.32/MT (Table 2.10). The greatest expense (74 percent) is for fortification with vitamin A, which alone costs about $3.79/MT. The cost of the micronutrients is slightly lower ($4.39/MT) for wheat flour since it is not enriched with the B-vitamins and iron. Based on metric tons distributed in 1993, the total costs of ingredients to enrich wheat flour and other processed foods, except rice, were $1.185 million and $1.267 million, respectively.

The concentration and number of vitamins and minerals are greater for the blended food supplements than what is used for enriching the processed and soy-fortified cereals (Table 2.11). The vitamins A, D, and E, calcium and phosphorous (tricalcium phosphate) cost $3.98, $4.35, $6.62, and $28.79 per MT, respectively, which represents about 92 percent of the total cost of all the fortificants in the blended foods. Because of the large quantity used and the price of tricalcium phosphate, it alone represents 60 percent of the cost of the fortification ingredients in the blended foods. Based on the amount of blended foods distributed in 1993, it is estimated that the total cost for vitamins was $5.511 million, and the total cost of minerals was $9.553 million.

Substantial economic benefits result from relatively modest investment in micronutrient programs (Levin et al., 1993; Behrman, 1993; Sanghvi, 1993). Improved micronutrient status provides benefits in reduced mortality and morbidity resulting in overall reduced medical and health expenditures, improved learning abilities, and increased labor productivity. Program approaches include diet diversification with vitamin and mineral rich foods, distribution of vitamin and mineral supplements, and food fortification. Costs associated with these various program approaches are difficult to estimate and compare and will vary from country to country. Although some studies have noted the relatively low costs for benefit return for vitamin and mineral supplement distribution, primarily of vitamin A and iron tablets, it has become clear that such programs, although important in emergency situations and for particular high risk groups, often suffer from logistical problems resulting in poor coverage and compliance and increased burden to already overloaded health care delivery systems (Gillespie et al., 1991; West and Sommer, 1987; Kuesch and Scrimshaw, 1986). More detailed studies of the economics of food fortification and other on-going micronutrient intervention strategies are needed (Nestel, 1993). Nevertheless, governments represented at the International Conference on Nutrition unanimously agreed that sustainable food-based approaches are to be given first priority particularly for populations deficient in vitamin A and iron (FAO/WHO, 1992b).

## F. Current Oversight of Specifications for Nutritional Quality

Requests for developing formulated foods originate from a variety of sources including cooperating sponsors (PVOs, intergovernmental organizations of the U.N.) recipient governments, USAID, USDA, DHHS, as well as private industry and trade associations. Previously, a USDA Committee on Processed Foods, made up of members of several government agencies, was responsible for screening new commodities. This Committee determined whether the proposed processed food was wholesome and acceptable under U.S. standards regarding nutritional value, composition, cost effectiveness, and whether it was culturally acceptable. The stability of the product for long-distance transport, storage and distribution was also evaluated. Final approval for the commodity was then given by the Commodity Credit Corporation (CCC).

In 1991, a USAID Joint Committee on Nutrition Specifications of Food Aid Commodities was formed to advise USAID on the nutritional specifications of food aid commodities. This standing Committee was established with permanent representation from technical and regional program areas of USAID, with USDA and outside experts as needed. This Committee has met twice since 1991, and it follows on the work of an earlier USAID ad hoc group that oversaw the work of the expert panel on the review of vitamin C and iron levels in food aid commodities.

## III. ISSUES CONCERNING MICRONUTRIENT CONTENT OF P.L. 480 TITLE II COMMODITIES

### A. Micronutrient Deficiencies and the Role of P.L. 480 Foods in Improving Micronutrient Intakes

To assess the role that Title II P.L. 480 commodities can play in reducing or preventing micronutrient deficiencies among beneficiary groups, it is first necessary to determine the extent to which the provision of P.L. 480 commodities contributes to improving the micronutrient intake by groups at nutritional risk, either directly or indirectly, and how cost-effective this approach is compared with other micronutrient supplementation. Second, it is necessary to determine to what extent inadequate dietary intakes contribute to these deficiencies relative to other contributing factors such as parasitic infections and disease.

Even though vitamin A and iron are seriously inadequate in many diets in the developing world, it must be noted that other nutrients also limit growth and physiologic functions in some instances. The addition of single nutrients such as vitamin A and iron may not alone reverse the problem.

The Title II program authorizes a broad spectrum of uses for donated foods which make it difficult to determine its impact on nutritional status and mortality rates (King, 1992). In part, due to the difficulty and expense of measuring nutritional outcomes, nutritional impact is not generally included as an objective in P.L. 480 programs even in targeted feeding programs. Consequently, the nutritional impact that any given program may have, particularly on micronutrient status, is difficult to determine. Information is not available to establish the contributions made by P.L. 480 food commodities to the micronutrient intakes of beneficiaries. However, it is generally assumed that the provision of various fortified and enriched, blended and processed foods is beneficial in preventing and, to a much lesser extent, correcting various micronutrient deficiencies. The indirect impact of P.L. 480 programs on micronutrient status, through income transfer and improvements in household food security, is recognized although it is also difficult to quantify. These aspects can be investigated as part of specific evaluation and management reviews of P.L. 480 programs as well as through further studies on household behavior and resource allocation.

For the purposes of this report, estimates of vitamin and mineral intakes have been made to illustrate the possible contributions that given rations of fortified blended commodities can make to cereal-based diets of targeted Title II beneficiaries - pregnant and lactating women, young children, refugees, and displaced people.

## A.1. Pregnant and Lactating Women and Young Children

Using the current fortification levels, calculations have been made to illustrate the potential micronutrient intake of selected beneficiaries receiving CSB as a supplement to different cereal-based diets.[2] The dietary needs of the young child and the pregnant woman are selected because they are the primary recipients of fortified blended foods. Given that Title II foods are designed to be used as a supplement to the locally available diet, it is assumed that dietary energy is derived from only cereals and oil, although a variety of other foods may also be included in the diet. Thus, this conservative approach assumes that energy needs are met predominately from the locally available cereal and some oil. Although it is recognized that local food sources would also contribute to the micronutrient content of the total diet, information on food consumption is not available to make these estimates. The assumption is made that the fortified blended food supplement would contribute approximately 25 percent of the total energy needs, based on recommendations made in the Commodities Reference Guide (USAID, 1988) and on information provided on the actual ration size used in selected programs. It should be noted that these calculations are for illustrative purposes only as most MCH programs rations are provided for home use and may be shared within the family, making it difficult to estimate actual intakes by mothers and children (Anderson, 1977; King, 1992).

Given the above assumptions, Tables 3.1 and 3.2 show the estimated micronutrient adequacy of cereal-based diets (rice, sorghum, cornmeal, or wheat) supplemented with CSB, for the pregnant woman and the young child, respectively. For both the young child and pregnant woman, depending on the base cereal of the diet, most dietary allowances for vitamins and minerals would be met, the exceptions being iron, zinc, and riboflavin, in the rice-based and the corn-based diets. Although zinc and iron levels are high in the wheat-based diet, their bioavailability is low. Calcium and phosphorus levels appear to be adequate in all diets. Information is not available on the iodine content of the diet.

Vitamin C levels would appear to be adequate, but the amount actually available after extended handling and cooking may be significantly less due to the poor stability of vitamin C.

Estimated levels of vitamin B-12 are excessive in all diets (425 percent RDA) due to high fortification levels. This is because fortification levels with vitamin B-12 are based on earlier dietary allowances which have since been reduced. The present RDAs for vitamin B-12 are one-third to one-half lower than those given in earlier recommendations (NRC, 1989). The current FAO vitamin B-12 allowances for pregnant women used as the basis for the calculations presented here are approximately one-half of the current RDA level (FAO/WHO, 1988). However, even if the higher levels presented in the RDAs were used, the estimated intakes would still be in excess of allowances.

Folic acid levels also exceed estimated needs in all diets for both the young child and pregnant women. Folic acid needs increase during pregnancy and lactation and the contributions made by fortified blended foods is important to maintain for women of child bearing age. The FDA has proposed to amend regulations that deal with the safe use of folic acid in foods (Fed. Reg., 1993).

Further reviews and analyses would be useful to serve as basis for ongoing review of fortification levels for other targeted groups and for other cereal based diets.

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[2] These calculations are based in part on a review conducted by Jensen (1977) on fortification levels of CSB.

## Table 3.1:
## Estimated Micronutrient Adequacy of Cereal Diets with Corn Soy Blend (CSB) Supplement for Pregnant Women (55kg)

| | | | Percent of Dietary Allowances Provided by Different Diets [1] | | | |
|---|---|---|---|---|---|---|
| Nutrients | Allowances [2] | | CSB & Oil Rice Diet | CSB & Oil Sorghum Diet | CSB & Oil Cornmeal Diet | CSB & Oil Wheat Diet |
| Energy (Kcal) | 2485 | (a) | 100 | 100 | 100 | 100 |
| Protein (g) | 60 | | 100 | 139 | 110 | 154 |
| Calcium (mg) | 1100 | (b) | 125 | 127 | 116 | 128 |
| Phosphorous (mg) | 1100 | (c) | 130 | 214 | 116 | 218 |
| Iron (mg) | 72 | (d) | 43 | 69 | 45 | 61 |
| Zinc (mg) | 15 | | 54 | 19* | 42 | 113 |
| Vitamin A (IU) | 2000 | (e) | 174* | 174* | 271 | 174* |
| Vitamin D (IU) | 400 | | 68* | 68* | 68* | 68* |
| Vitamin E (mg) | 10 | | 123 | 117 | 132 | 181 |
| Vitamin C (mg) | 30 | (b) | 200 | 200 | 200 | 200 |
| Thiamine (mg) | 1.5 | | 75 | 134 | 97 | 181 |
| Riboflavin (mg) | 1.5 | | 59 | 91 | 60 | 83 |
| Niacin (mg) | 17 | | 100 | 144 | 84 | 226 |
| Pantothenate (mg) | 4-7 | | 143-250 | 73-128* | 94-164 | 145-254 |
| Pyridoxine (mg) | 2.2 | | 67 | 32* | 88 | 104 |
| Folacin (mcg) | 370-470 | (e) | 103-131 | 95-121* | 143-182 | 138-175 |
| Vitamin B12 (mcg) | 1.4 | (e) | 425* | 425* | 425* | 425* |
| Iodine (mcg) | 200 | | 33* | 33* | 33* | 33* |

(1) Assumes CSB supplement provides 25% of energy needs, approximately 150g/day. Remaining energy derived from 20g of oil and staple cereal.
(2) Source: NRC/NAS RDAs 1989, unless otherwise noted.
(a) Based on FAO equations in NRC/NAS, 1989.
(b) FAO/WHO 1974.
(c) Assumed to provide 1:1 calcium:phosphorus ratio.
(d) DeMayer, 1989.
(e) FAO/WHO, 1988
* Values not available for cereal;therefore, level represents amount contributed solely by CSB.

## Table 3.2:
## Estimated Micronutrient Adequacy of Cereal Diets with Corn Soy Blend (CSB) Supplement for Young Children (1-3 years old)

| | | | Percent of Dietary Allowances Provided by Different Diets [1] | | | |
|---|---|---|---|---|---|---|
| Nutrients | Allowances [2] | | CSB & Oil Rice Diet | CSB & Oil Sorghum Diet | CSB & Oil Cornmeal Diet | CSB & Oil Wheat Diet |
| Energy (Kcal) | 1300 | (a) | 100 | 100 | 100 | 100 |
| Protein (g) | 16 | | 194 | 275 | 214 | 305 |
| Calcium (mg) | 500 | (b) | 136 | 139 | 126 | 142 |
| Phosphorous (mg) | 500 | (c) | 147 | 246 | 130 | 253 |
| Iron (mg) | 22 | (d) | 70 | 116 | 74 | 103 |
| Zinc (mg) | 10 | | 42 | 15* | 33 | 98 |
| Vitamin A (IU) | 1333 | (e) | 130* | 130* | 208 | 130* |
| Vitamin D (IU) | 400 | | 37* | 37* | 37* | 37* |
| Vitamin E (mg) | 6 | | 103 | 97* | 111 | 132 |
| Vitamin C (mg) | 20 | (b) | 150 | 150 | 150 | 150 |
| Thiamine (mg) | 0.7 | | 83 | 150 | 105 | 205 |
| Riboflavin (mg) | 0.8 | | 61 | 93 | 64 | 86 |
| Niacin (mg) | 9 | | 103 | 141 | 80 | 225 |
| Pantothenate (mg) | 3 | | 173 | 85* | 111 | 177 |
| Pyridoxine (mg) | 1 | | 77 | 35* | 100 | 121 |
| Folacin (mcg) | 50 | (e) | 488 | 446* | 688 | 664 |
| Vitamin B12 (mcg) | 0.5 | (e) | 596* | 596* | 596* | 596* |
| Iodine (mcg) | 70 | | 48* | 48* | 48* | 48* |

(1) Assumes CSB supplement provides 25% of energy needs, approximately 75g/day. Remaining energy derived from 10g of oil and cereal.
(2) Source: NRC/NAS RDAs 1989, unless otherwise noted.
(a) Based on FAO equations in NRC/NAS, 1989.
(b) FAO/WHO 1974.
(c) Assumed to provide 1:1 calcium:phosphorus ratio.
(d) DeMayer, 1989.
(e) FAO/WHO, 1988
* Values not available for cereal;therefore, level represents amount contributed solely by CSB.

**Table 3.3:**
**Micronutrient Deficiencies in**
**Refugee Camps, 1984 - 1993**

| Disease | Year | Location |
|---|---|---|
| **Scurvy** | 1984<br>1985<br>1989<br>1991<br>1993 | Sudan<br>Somalia<br>Ethiopia<br>Sudan<br>Nepal(Bhutanese) |
| **Beriberi** | 1985<br>1990<br>1993 | Thailand<br>Guinea (Liberians)<br>Nepal (Bhutanese) |
| **Xerophthalmia** | 1985 | Sudan |
| **Pellagra** | 1989<br>1990 | Malawi (11 camps)<br>Malawi (11 camps) |
| **Iron Deficiency Anemia** | 1990 | Syria,Jordan,<br>West Bank & Gaza |
| | 1990 | Ethiopia |

Source: Updated from Toole, 1993.

## A.2. Displaced People and Refugees

Concerns of micronutrient deficiencies in refugee populations were reflected in the Plan of Action adopted at the International Conference of Nutrition:

> *"Recognize that refugees and displaced persons, as well as being susceptible to iodine, vitamin A , and iron deficiencies, are also susceptible to other deficiencies, particularly vitamin B1 (beriberi), niacin deficiency (pellagra) and vitamin C deficiency (scurvy). Donor countries and involved organizations must therefore ensure that the nutrient content of food used for emergency food aid meets nutritional requirements, if necessary through fortification and supplementation."* (FAO/WHO, 1992b)

Deficiencies of niacin, vitamin C, thiamine, riboflavin, as well as of vitamin A, iron, and iodine have been documented among refugee populations in Malawi, the Horn of Africa, and Asia as noted in Table 3.3. Regardless of the clinical deficiency observed, malnutrition almost always occurs as a multiple deficiency syndrome, correction of which requires the provision of adequate amounts of all deficient micronutrients as well as energy and protein.

Guidelines for providing general rations in emergency situations are specified in the Supplement on Emergency Rations for long-and short-term use (USAID, 1993c). The document states that emergency feeding over an extended duration will require the addition of local or other imported foods to meet nutritional needs, because emergency rations are largely composed of cereals to meet energy and protein needs, but not necessarily micronutrient needs.

Based primarily on documented outbreaks of scurvy (Magan et al., 1983; Seaman and Rivers, 1989; LRCRCS, 1985) and pellagra (CDC, 1991) the issue of fortifying appropriate food aid commodities has been raised (Harrell-Bond et al., 1989). Concerns have centered on fortifying bulk food aid commodities (Henry and Seaman, 1992) as well as making the highly fortified blended foods more widely available, which normally are only available in supplementary feeding programs (Toole, Personal Communication, 1994). While improving the access to and availability of culturally acceptable foods, including fruits, vegetables, and animal products rich in a variety of micronutrients is the ideal solution, it is often not possible due to logistic problems and high costs. The distribution of vitamin and mineral tablets is another option, and has been done in Somalia (vitamin C) and southern Malawi (B complex), although difficulties in compliance and distribution exist.

By examining various ration packages that have been made available to refugees/ displaced people, potential micronutrient shortfalls can be identified based on the type of consumed cereal assuming that rations are the sole source of food (Hansch, 1992; Toole et al., 1989). P.L. 480 Title II commodities used for refugee and displaced persons are whole grains, oil, pulses, and to a lesser extent processed cereals. For the purposes of this report, information was obtained on rations that are currently being distributed in refugee/displaced situations within Africa (World Vision, Personal Communication, 1994).

Calculations were made to estimate the micronutrient content of rations in relation to recommended dietary allowances for an adult male. Clearly, adequate amounts of energy and protein are needed in addition to adequate levels of micronutrients. The corn-based ration in Mozambique and the wheat-based ration in Ethiopia, both of which include beans and oil, provided approximately 2000 and 1955 kilocalories and 54 and 73g of protein, respectively (Table 3.4). In the corn-based ration in Mozambique, the levels of vitamin C, pyridoxine, vitamin B-12, riboflavin, pantothenic acid, iron, zinc, and calcium were low. Because much of the niacin provided by corn is poorly available, niacin would also be low. In the wheat-based ration in Ethiopia, the levels of vitamin C, vitamin A, riboflavin, vitamin B-12, iron, and calcium were low. The zinc in whole wheat has low bioavailability[3], thus the availability of zinc is low. Data were not available for iodine content; however, in both diets, the iodine content would be dependent on the soil and water content where the crops were grown.

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[3] Bioavailability as used in this report refers to the proportion of the ingested nutrient that is absorbed and available for use by the body.

**Table 3.4:**
**Estimated Micronutrient Adequacy of Corn-Based and Wheat-Based Rations Provided for Refugees and Displaced People**

| | | Percent of Dietary Allowances Provided | |
|---|---|---|---|
| Nutrient | Allowances (1) | Corn-based Ration (2) | Wheat-based Ration (3) |
| Energy (Kcal) | 2200(a) | 92 | 89 |
| Protein (g) | 50(a) | 123 | 166 |
| Calcium (mg) | 500(b) | 21 | 41 |
| Phosphorous (mg) | 500(c) | 239 | 333 |
| Iron (mg) | 23 | 68 | 82 |
| Zinc (mg) | 15(d) | 76 | 97 |
| Vitamin A (IU) | 2000 | 93 | 1 |
| Vitamin D (IU) | 800(d) | NA | NA |
| Vitamin E (mg) | 10(d) | NA | NA |
| Vitamin C (mg) | 30(a) | 15 | 12 |
| Thiamine (mg) | 1.2(b) | 175 | 179 |
| Riboflavin (mg) | 1.8(b) | 60 | 67 |
| Niacin (mg) | 19.8(b) | 87 | 141 |
| Pantothenic Acid (mg) | 4-7(d) | 59 | 73-128 |
| Pyridoxine (mg) | 2.0(d) | 28 | 113 |
| Folacin (mcg) | 200 | 152 | 222 |
| Vitamin B-12 (mcg) | 1.0 | 0 | 0 |
| Iodine (mcg) | 150(d) | NA | NA |

(1) FAO/WHO, 1988, unless otherwise noted Allowances for adult male
(2) Monthly ration: 13.5kg corn, 1 8kg beans, 0.6kg veg. oil World Vision (pers communication) June 1994
(3) Monthly ration. 15kg wheat, 1.5kg beans, 0.5kg veg. oil World Vision (pers communication) June 1994.
(a) USAID/BHR, Draft Supplement on Emergency Rations-Commodities Reference Guide, June 1993
(b) FAO, 1974.
(c) Assumed 1:1 ratio for calcium and phosphorus
(d) NRC/NAS, 1989
NA- nutrient data not available

Options to improve the micronutrient content of rations for long-term use have been suggested, including the feasibility of improving the micronutrient content of whole grains through fortification. The appropriateness and feasibility of this approach is discussed in Section IV.4. In some cases, where central milling facilities are not available, makeshift efforts have been implemented to add vitamins and minerals on site, such as was done in Malawi with cement mixers (Comments by Seaman in ACC/SCN, 1993). Although this may be necessary under certain emergency circumstances, proper quality control and food safety standards would be difficult to achieve.

## B. Concerns of Bioavailability and Safety of Added Micronutrients

### B.1. Iron

#### B.1.1 Iron - Bioavailability

When foods are fortified with iron compounds the bioavailability of the fortificant iron is as important as the total amount consumed in the diet in order to maintain iron balance. Dietary iron absorption is influenced primarily by 1) the iron status of the individual consuming the food, 2) the amounts of heme and non-heme iron consumed and the types of non-heme iron consumed and 3) the levels of 'enhancing' or 'inhibiting' substances in the total diet. The factors which determine the bioavailability of dietary iron, including the adaptations that occur in iron deficient individuals, have been documented (Charlton and Bothwell, 1983; Cook, 1990; Cook et al., 1972, 1976; Hallberg, 1981; INACG, 1982; MacPhail and Bothwell, 1993; Monsen, 1988).

Generally, absorption of iron from the diet varies from 2-30 percent, with considerable variation among people. The iron status of the individual markedly affects iron uptake, with more absorbed by iron-deplete individuals and less by those in iron balance. This ability to modify iron absorption in relation to status enables a healthy individual to adapt to a considerable range of dietary iron levels. The high physiological requirement for iron by young children for growth and by women of reproductive age to compensate for menstrual losses and the demands of pregnancy, place these groups at risk of iron deficiency anemia.

Heme iron, found in animal tissue as hemoglobin or myoglobin, remains intact as a complex in the gastrointestinal tract until the iron is released for absorption. Heme iron is highly bioavailable, with between 20-25 percent usually being absorbed. However, the amount of heme iron is very low in diets containing little meat, and represents no more than 10 percent of the dietary iron even in western diets. The rest of the dietary iron, known as non-heme iron comes primarily from plant foods, contaminant iron, and in some instances, iron fortificants.

Non-heme iron is solubilized to varying degrees by stomach acid, and becomes part of the non-heme iron pool in the lumen of the upper intestinal tract, where it is available for absorption. Absorption of non-heme iron is improved by enhancer substances, e.g., vitamin C, animal tissue and sulfhydryl containing amino acids and peptides. Non-heme iron can also be bound by other dietary components, such as phytates, polyphenols, and tannins, and be rendered unavailable for absorption. Calcium, certain proteins in some soybean products, and casein may also inhibit iron uptake (Cook and Monsen, 1976; INACG, 1982).

In diets composed largely of cereals and legumes, iron bioavailability is generally low. Iron is poorly absorbed from cereal and legumes with the exception of wheat of 60-80 percent extraction, which is low in iron. Refining and processing soy products does not materially improve iron bioavailability (INACG, 1982).

Monsen (1988) reported that vitamin C and other organic acids (e.g., citrate and lactic) enhances the uptake of iron, and that this effect is greatest in diets of low bioavailability. Vitamin C can improve absorption of non-heme iron and overcomes the inhibitory effects of tannins in tea, calcium, and phosphates (Lynch and Cook, 1980; Derman et al., 1980). To be effective, vitamin C must be present when the food is eaten. However, vitamin C is readily oxidized and destroyed when

food is cooked at high temperatures (bread baking) or when exposed to air and prolonged heat. INACG (1982) recommended that corn-soy blended foods be fortified with an adequate amount of stabilized ascorbic acid in order to improve the bioavailability of the fortificant iron.

Cook and Reusser (1983) reviewed the sources of iron that can be used as fortificants. Soluble forms of iron, such as ferrous sulfate, are most likely to be better absorbed when added to foods, but are likely to produce changes in color, odor, and taste if stored for long periods (Barrett and Ranum, 1985). The need to select iron fortificants that will not react when added to a food vehicle has frequently led to considerable compromises and reduced bioavailability. This is exemplified by the use of insoluble forms of elemental iron including reduced, electrolytic, and carbonyl iron. If the particle size is sufficiently small, some of these forms are solubilized in the stomach. Hallberg et al. (1986) have shown low and highly variable bioavailability of carbonyl iron which raises questions about its use, especially in cereal-legume-based diets that are high in substances inhibiting iron absorption.

Ferrous sulfate is widely used to enrich wheat flour in the USA; however, wheat flour distributed through P.L. 480 Title II programs is not enriched with iron. Ferrous fumarate, which is somewhat less soluble than ferric sulfate, is used to fortify the Title II blended foods, namely CSB and WSB. Both of these blended foods contain 40mg of stabilized vitamin C per 100g but final levels are uncertain due to the instability of vitamin C. The bioavailability of ferrous fumarate iron is comparable to that of ferrous sulfate (Hurrell et al., 1993)

Reduced iron is used to fortify or enrich the P.L. 480 Title II soy-fortified cereals, bulgurs and cornmeal. The bioavailability of this form of iron is likely to be low due to its poor solubility, especially where ample amounts of ascorbic acid or other enhancers are not present.

Because of the need to protect the non-heme iron from inhibitors commonly present in plant food diets, studies have been conducted with chelating agents in an attempt to protect iron from combining with competitive inhibitor ligands which renders the iron unavailable for absorption. This has led to a number of studies on the suitability of sodium iron ethylenediaminetetraacetic acid (NaFeEDTA) and related compounds (INACG, 1993). Both NaFeEDTA and disodium EDTA plus ferrous sulfate have improved iron absorption, presumably by reducing the inhibitory effects of wheat phytate and high bread-baking temperatures. NaFeEDTA and EDTA are stable, compatible with most food vehicles, and give rise to only slight changes in color and taste of the foods.

MacPhail (1981) reported that molar ratios of disodium EDTA:iron of 0.25, 0.5, and 1.0 increase iron absorption 3.0, 3.5, and 2.3-fold, respectively, when added to a rice-based diet. However, a significant depression in iron absorption was observed when disodium EDTA and ferrous sulfate were added to a meal containing no inhibitors of iron absorption. This study indicates that when diets of poor iron bioavailability are consumed, fortification with disodium EDTA with a simple iron salt in a EDTA:iron molar ratio of 1.0 or less may increase iron absorption.

INACG (1993) reviewed the relative bioavailability of iron from ferrous sulphate or NaFeEDTA in 13 different food combinations from eight studies. The bioavailability of iron from NaFeEDTA fortified foods ranged from 4.5 to 16.8 percent, while that from ferrous sulphate varied depending on the proportion of enhancer and inhibitor substances known to be present. With one exception, between 2.1 and 2.9 times as much iron was absorbed in the presence of EDTA. When data from 25 studies involving NaFeEDTA were analyzed, it was concluded that at least 10 percent of

the fortificant iron would be absorbed by iron-depleted individuals from all but the most inhibitory combinations of foods.

The use of NaFeEDTA was provisionally considered by the Joint FAO/WHO Expert Committee on Food Additives (WHO, 1993) to be safe for use in food fortification programs in populations in which iron deficiency anemia is endemic. At the same time the Committee emphasized that its evaluation applies only to the use of NaFeEDTA as a dietary supplement to be used under supervision, and expressed its concern about the potential for over-fortification of food because of the enhanced bioavailability of iron in this form. The Committee also requested that additional studies be conducted to assess the metabolism of NaFeEDTA with long-term administration.

The possible use of NaFeEDTA for iron fortification in selected P.L. 480 Title II commodities may provide an opportunity for reducing widespread iron deficiency anemia. Its use does not require additional vitamin C for assimilation of iron. The adverse effects on iron absorption by inhibitor substances, i.e., phytate, polyphenols, and tannins, and problems of storage, handling, and cooking practices appear to be reduced. Food grade purity of NaFeEDTA is not commercially available, but an agricultural grade for fertilizer has been used commercially for many years. Moreover, food grade disodium EDTA and calcium disodium EDTA have been used by the food industry for several years to inhibit oxidation by metal catalysts such as iron and copper. It is expected, therefore, that food grade NaFeEDTA could be manufactured in sufficient quantities for food fortification at a cost similar to that for food grade calcium disodium EDTA and disodium EDTA.

### B.1.2 Iron - Safety Factors to Consider in Iron Fortification

Concerns about the possible adverse effects of iron fortification of foods relate to chronic iron overload as found in hemochromatosis and the potential interactions with other trace elements in the diet, particularly zinc and, to a lesser extent, copper. Deleterious effects of iron fortification on health are unlikely in programs where iron fortified foods are targeted to vulnerable populations with widespread iron deficiency. According to Finch and Monsen (1972), daily iron intakes between 25 and 75mg are unlikely to have an adverse affect in individuals with normal iron stores.

Idiopathic hemochromatosis, an inherited condition found in caucasian populations, can lead to chronic iron overload. Bothwell et al. (1978) concluded that the absorptive mechanism in individuals with this genetic trait responds to the same influences as in normal people, but that there is a higher set point. As iron stores rise, absorption rate declines. Exposure of such individuals to higher levels of dietary iron over many months or years could accelerate iron overload. However, iron overload occurs primarily in men and post-menopausal women with this genetic defect, thus it is not a problem in the target population of the P.L. 480 programs, whose iron requirements are high due to requirements for growth (young children) and menstrual losses (women of reproductive age).

There do not appear to have been any reports of iron toxicity from foods among people without genetic defects, except where there is long-term consumption of home brews made in iron vessels. Accidental poisoning from ingestion of iron supplements has been observed in the USA. The lethal dose of ferrous sulfate for humans is approximately 200-250mg/kg body weight (NRC, 1979).

The iron fortificant levels currently being used as well as the USAID technical panel recommendation to increase the level of ferrous fumarate from 15 to 30mg iron per 100g of blended food are deemed safe for targeted use in areas where iron deficiency anemia is endemic. Whether there is a need to 'double' the present level of ferrous fumarate is discussed in Section IV. When devising generic food mixtures suitable for both pregnant women and children, careful attention must be given to prevent excessive consumption of iron by young children whose requirements are less. Also, the possibility that elevated iron intakes may reduce the bioavailability of other essential trace minerals needs to be considered.

Even though iron deficiency anemia in women and children is endemic in many parts of the developing world, dietary iron intakes are usually only one of the causes involved. Blood loss from any cause including menstrual losses, parasitic infestation (notably hookworm), malaria, and other inflammatory conditions of the gastrointestinal tract can lead to blood loss and anemia. Deficiencies of folic acid and vitamin B-12 also result in anemia. Consequently, the several possible causes of anemia should be considered in its proper diagnosis and effective prevention/treatment (Levin et al., 1993).

### B.1.3 Iron - Nutrient Interactions/Competition

Dietary levels of specific minerals may affect the absorption of other minerals. Modifying the dietary level of either iron, zinc, or copper may influence the bioavailability and uptake of the others (Gordon, 1987). Iron-fortified infant formulae are associated with reduced copper absorption in infants (Haschke et al., 1986). Solomons and Jacob (1981) reported that ratios of iron and zinc of 1:1 from ferrous sulfate and zinc sulfate slightly reduce zinc absorption, while ratios of 2:1 and higher substantially inhibit zinc uptake in the human intestine. A similar study was also reported in human infants and pregnant women (Solomons, 1986). The occurrence of zinc deficiency in wheat-eating populations have been observed in Egypt (Sandstead et al., 1967; Prasad and Oberleas, 1970) and in Iran (Halsted et al., 1972, 1974), and is characterized by retarded growth and impaired sexual development, especially in pre-adolescence.

In view of the widespread occurrence of endemic iron deficiency anemia in the developing world, concerns of mineral interactions should not prevent the fortification of specific foods for targeted groups in iron deficient areas. However, caution should be exercised before excessively high levels of iron are used to fortify foods for young children and pregnant women. Little is known about whether there is any adverse effect of iron fortification on copper adequacy, and there is no evidence to indicate that copper intakes are marginal in the developing world.

### B.1.4 Iron - Safety of EDTA Intakes

In studies with swine, Candela et al. (1984), using double-labeled NaFeEDTA administered orally, found that iron and EDTA were absorbed independently. About five percent of the EDTA administered was absorbed and excreted in the urine, while the remainder was excreted in the feces. It is presumed that the EDTA which is absorbed and excreted without its original iron was bound to other elements from the gastrointestinal tract. About five percent of the iron was absorbed, and only one percent of the dose was excreted in the urine. These findings confirm earlier work in humans by MacPhail et al. (1981) that most of the ingested iron absorbed becomes available for physiological function.

There have been no studies on the toxicity of FeNaEDTA in animals; indeed, the information on toxicity is based on other EDTA compounds. In chronic toxicity studies in rats, Oser et al. (1963) reported that feeding rats calcium disodium EDTA at levels up to 250mg/kg body weight had no adverse effects through four successive generations. These results were used by the FAO/WHO Joint Expert Committee on Food Additives (JECFA) to calculate the acceptable daily intake (ADI) for EDTA as being 2.5mg/kg for EDTA (Whittaker et al., 1993). As Whittaker et al. point out, the zinc adequacy of diets should be considered in interpreting EDTA toxicity data. Teratogenic effects of high dietary levels (one percent) of EDTA observed by Swenerton and Hurley (1971) during pregnancy in rats fed low zinc diets, were preventable with additional dietary zinc. This indicates that the adverse effect of EDTA was caused by its inhibition of the uptake of zinc, rendering the animal zinc deficient.

Forbes (1961), on the other hand, found that growth of rats fed a low-zinc diet was improved when 230ppm of sodium EDTA was included, indicating that the lower level of EDTA actually improved the absorption of zinc. Similar results were obtained by Kratzer et al. (1959). Hurrell et al. (1993), in their studies on rats, showed that the molar ratio of EDTA and zinc or copper in the diet influenced the effect of EDTA on the absorption and retention of these minerals. Increasing the EDTA:zinc molar ratio from 7:1 to 19 or 37:1 in a diet containing 6.1mg of zinc per kg increased both zinc absorption and excretion. Zinc retention at the highest level (ratio 37:1) was higher than that observed with no dietary EDTA, but it was lower than that obtained with the intermediate level diet with an EDTA:zinc ratio of 19:1. Likewise copper absorption and retention was improved at EDTA:copper ratios of 11.2:1, but not at ratios of 4.1 or 22.4:1. Much more information is needed about the influence of EDTA on availability of trace elements.

According to INACG (1993), unpublished results in humans have confirmed that zinc absorption is improved by NaFeEDTA at a molar ratio of EDTA to zinc of 3.3:1. Solomons et al. (1979), Viteri et al. (1983), and Ballot et al. (1989), however, observed no significant changes in serum zinc in humans in field trials with NaFeEDTA.

EDTA compounds are not Generally Recognized as Safe (GRAS) in the USA, nor is NaFeEDTA approved for use in foods in the US. However, EDTA is currently used in the disodium or calcium disodium form in the US and a few other countries, primarily in canned and some dried foods as sequestering agents to preserve color, texture, and prevent rancidity and off-odors. Overall exposure to EDTA by the USA population has been estimated to be 15mg per day (Whittaker et al., 1993). The populations most likely to consume P.L. 480 commodities can be expected to have almost no intake of EDTA in their present food supply.

In summary, there is no basis for safety concerns with the use of NaFeEDTA as a fortificant for improving the bioavailability of iron at ratios of EDTA to total iron of approximately 0.5:1 in target populations where iron deficiency anemia is endemic and diets are adequate in zinc.

### B.2. Vitamin A - Fortification Levels and Adverse Affects

Baurenfiend (1980) reported that symptoms of vitamin A toxicity usually occur only after sustained daily intakes of at least 6,000mcg (20,000IU) and 15,000mcg (50,000IU) in children and adults, respectively. WHO (1982) reported that 1 to 3 percent of children receiving single doses of 200,000IU exhibited transient signs of toxicity with no lasting effects.

Of greatest concern is the occurrence of spontaneous abortions and birth defects of infants among women taking therapeutic oral doses of vitamin A (0.5 -1.5mg of retinoic acid) during the first trimester of pregnancy (Lammer, 1985). Daily doses of retinyl esters or retinol (20,000IU or more) appear to be equally toxic (Costas et al., 1987; Miller et al., 1987; Strange et al., 1978).

Scientists appear to agree that 10,000IU of vitamin A is a safe level of daily intake for use as a maximum in food fortification programs, recognizing that this level could be doubled before any risk of toxicity is likely. Where vitamin A is added in more than one food vehicle, the amounts of each likely to be consumed on a regular basis, especially by women and young children, must be determined in order to estimate the total amount of vitamin A that will be ingested.

Present fortification levels with vitamin A (2000IU/100g in the blended, protein-fortified and "enriched" foods) would supply 10,000IU if 500g of the combination of these commodities were consumed. This assumes that these levels are present at the point of consumption. The addition of vitamin A to vegetable oil supplied in these same programs, which is an option to be considered, could result in intakes of more than 10,000IU/day unless the vitamin A fortification of other commodities or the amounts of other commodities consumed are reduced.

Vitamin A is unstable when exposed to air, light, and heat (Table 3.5), and some of it is destroyed in the process of cooking. Proper storage of vitamin A and foods containing vitamin A is important to minimize its degradation.

**Table 3.5:**
**Stability of the Vitamins Affected by Different Conditions**

| Nutrient | Effect of pH | | | Air or Oxygen | Light | Heat | Relative Cooking Losses (%) |
|---|---|---|---|---|---|---|---|
| | Neutral (pH7) | Acid (<pH7) | Alkaline (>pH7) | | | | |
| Vitamin A | S | U | S | U | U | U | 40 |
| Vitamin C | U | S | U | U | U | U | 100 |
| Carotene (pro-A) | S | U | S | U | U | U | 30 |
| Cobalamin (B-12) | S | S | S | U | U | S | 10 |
| Vitamin D | S | S | U | U | U | U | 40 |
| Folic acid | U | U | S | U | U | U | 100 |
| Vitamin K | S | U | U | S | U | S | 5 |
| Niacin | S | S | S | S | S | S | 15 |
| Pyridoxine (B-6) | S | S | S | S | U | U | 40 |
| Riboflavin (B-12) | S | S | U | S | U | U | 75 |
| Thiamine (B-1) | U | S | U | U | S | U | 80 |

Source: Henry and Seaman, 1992
S - stable, U - unstable

## B.3. Niacin

In cereal grains, up to 70 percent of the niacin is structurally bound so that it is unavailable unless the cereal has been treated with lime (Goldsmith et al., 1956). Niacin can be converted in the body from dietary tryptophan, an amino acid, if the level is higher than needed to meet the requirements for protein synthesis. To compute the amount of niacin that may be synthesized from tryptophan in assessing the dietary adequacy of niacin, it is assumed that one milligram of niacin will be made from 60mg of dietary tryptophan (Horwitt et al., 1981). Niacin and tryptophan levels are especially important in areas where high-corn, low-animal product diets are consumed because corn is low in both available niacin and tryptophan.

Like other water-soluble vitamins, niacin is not stored appreciably in the body, and excesses are readily excreted in the urine. However, niacin is one of the most stable vitamins, being essentially unaffected by light, heat, or air (oxidation) at acid, neutral or alkaline pH (Table 3.5).

## B.4. Vitamin C

Vitamin C (ascorbic acid) is naturally present in fruits and vegetables, but not in cereal grains or most legumes. It is water-soluble, and like niacin, excesses are readily excreted from the body so that only limited body stores exist. Vitamin C is one of the most unstable of all the vitamins, being susceptible to oxidation in the presence of air, heat, alkaline pH, and light (Table 3.5). Vitamin C used in blended foods is coated for protection against contact with oxygen, and it remains reasonably stable as long as the coating remains intact. High moisture levels (9 percent or higher) lead to more rapid losses during storage, especially at elevated temperatures.

Cooking causes losses of vitamin C in foods. Frequent stirring of air into food during or after cooking causes greater losses of vitamin C. It is less labile in an acid medium. Forty milligrams of ascorbic acid are added per 100g of blended foods (CSB, WSB) which require only one or two minutes of boiling in preparation. If these are properly stored and not exposed to heat for extended periods, much of the vitamin C added in fortification would likely be present when the food is consumed. Vitamin C is not only important in the prevention of scurvy, but it also enhances iron absorption.

Dietary intakes of 20 to 80 times the RDA for vitamin C appear safe in humans. Gastrointestinal disturbances, diarrhea, and slight increases in urinary oxalate excretion are the only adverse effects reported at high doses. However, it is not clear whether these low-magnitude effects, which are within the range of normal variation, are associated with increased risk of forming urinary calculi (Combs, 1992). Excess vitamin C is readily excreted in urine.

## B.5. Iodine

The RDAs for iodine for 1-3 and 4-6 year old children are 70 and 90mcg per day, respectively. The RDA for adults is 150mcg of iodine per day. Intakes of up to two mg/day in adults and one mg/day in children have produced no indications of physiological abnormalities (Crocco and White, 1981). Naturally occurring goitrogens, as found in some cassavas and the cabbage family, have been associated with the incidence of goiter in some parts of the world, and goiter caused from high levels of iodine intake have been documented in Japan (Nagataki, 1974).

In many countries salt is fortified with iodine (76mcg of iodine/g salt in USA) to ensure adequate intakes and prevention of IDD. Levels between 20 to 50mg iodine/kg salt or 25 to 50mcg iodine/g salt have been recommended (ICCIDD, 1990). Both potassium iodate and potassium iodide can be used in fortification but the former is more stable than the latter. The blended P.L. 480 commodities, CSB and WSB, contain 0.65 percent and 0.75 percent iodized salt, respectively. This provides 45 and 52mcg of iodine per 100g of CSB and WSB, respectively.

## C. Stability of Added Nutrients in Title II Commodities

Henry and Seaman (1992) have summarized the factors that influence the stability of added vitamins in most food systems as follows:

- Temperature of storage
- Moisture content
- Presence/absence of light
- pH of system
- Presence/absence of trace elements

Table 3.5 shows the stability of vitamins under various conditions. Niacin is the most stable, and vitamin C is the most labile of all the vitamins.

### C.1. Evaluation of Micronutrient Stability and Variability in P.L. 480 Title II Commodities

The USDA Federal Grain Inspection Service (FGIS) conducted a survey on CSB, WSB, and soy-fortified cornmeal (SFCM) to determine levels of iron, niacin, vitamin A, and vitamin C, as applicable (SFCM contained no added vitamin C). In addition, FGIS randomly selected 15 bags filled with 25kg of CSB, WSB, and SFCM produced at that time, for a micronutrient shelf-life study with and without polyethylene over-wrap for additional protection during storage.

It was concluded that enhanced packaging did not increase the shelf-life of vitamins A and C during storage for seven months. Furthermore, the results of the analyses of the traditionally packaged commodities indicated an unusual variance in micronutrient levels including iron, which should be quite stable. For both vitamins A and C there was a general downward trend in concentration with increasing time for all commodities tested (Harte et al., 1992). However, there was considerable month to month variation which could have been due to inadequate blending of the vitamin premix within the commodities, either within and/or between bags. The large variability observed in the iron data indicates that blending of the mineral mix into the commodities was also inadequate. Identification of inadequate mixing of the premixes into the blended foods at the mill level has initiated new quality control procedures by ASCS as discussed below.

The Technical Review Group, convened in July 1990, recommended that the level of iron from ferrous fumarate be increased from 15 to 30mg per 100g in the blended food commodities, and that the level of added iron from reduced iron be increased from 2.9 to 4.4mg/100g to 8.8mg/100g in all protein fortified and other processed foods. A study commissioned by USAID Bureau for Humanitarian Response was undertaken to determine if these increases in iron fortification would affect the sensory properties of CSB, WSB, and SFCM. The study found no significant differences in

overall flavor quality between the currently used (15mg iron/100g) and the increased levels (30mg iron/100g) of added iron for all the commodities with the exception that the wheat flavor of WSB after nine months of storage was different in the sample containing the highest level of ferrous fumarate. No explanation was given for this difference, and it was concluded from the overall flavor quality ratings that there would be no detrimental effect if iron levels were increased.

Other sensory evaluations on samples of CSB and WSB stored at 27°C for two months by ARS/USDA (Bookwalter, 1991) did reveal slight "stale" and "cardboard-like" off-flavors when the higher level of iron was added. There was no change in peroxide values (indicates lipid oxidation) when the level of iron from ferrous fumarate was increased to 30mg/100g. Additional testing is needed to assure that off-flavors caused by iron catalyzed oxidation will not develop before increasing substantially the amount of ferrous fumarate added to these blended foods. The vitamin C retention was 93 percent and 83 percent in the low and high iron samples, respectively, but the variability precluded significance between the two levels.

The FDA has also analyzed vitamin C levels in samples of CSB and WSB stored for 7 and 10 months at 27°C. Although there was no baseline, the values showed no loss between 7 and 10 months. Vitamin A assays also were done on samples stored for 2, 7, and 10 months at 27°C. There appeared to be good agreement between the 2 and 7 month values, but the values after 10 months of storage showed considerable variability indicating either that some loss of vitamin A had occurred after 7 months of storage, or that there was variability among the samples taken from the same bag due to incomplete blending.

### C.2. Analysis of Field Samples (Iron, Vitamins A and C)

In an effort to determine the amounts of vitamin A, vitamin C, and iron actually present in CSB and WSB at the point of use, 36 samples were taken in the field in seven different countries. Multiple 400g samples were collected and sent back for analysis by FDA. The results are shown in Tables 3.6a and 3.6b. The values for iron, as well as for both vitamins A and C, show marked variation. Since iron is stable, variation in the values for iron indicate either that 1) the mineral premix did not contain the certified level of iron, 2) the iron was not properly mixed in the premix when added to the blended food, 3) the mineral premix was not accurately added to the blended food and adequately mixed, or 4) that settling within a bag occurred and this was not compensated when taking the 400g sample.

Nine of the 36 samples had unacceptably low iron values (ranging from 3.6 to 10.6mg iron/100g) and one had a very high iron value (45.7mg iron/100g) (Table 3.6a). It is assumed that these variations in iron were the result of inadequate mixing of the mineral premix in the blended foods. In almost every case, the values for both vitamin A and vitamin C were similarly low (or high in the one with high iron), illustrating that neither the vitamin premix nor the mineral premix were added in correct amounts and properly mixed in the bags sampled. In six additional samples, both of the vitamin levels were low (four cases) or high (two cases), while the iron level was appropriate (Table 3.6a) indicating again that in these bags the mineral premix was adequately blended but the vitamin premix was not.

**Table 3.6(a):**
**Vitamin A, Vitamin C, and Iron Content in Field Samples of Corn Soy Blend (CSB) and Wheat Soy Blend (WSB)**

| Country | Sample | Quantities in 100g of Commodity | | | Moisture (%) |
|---|---|---|---|---|---|
| | | Vitamin C (mg) | Vitamin A (IU) | Iron (mg) | |
| Samples with aberrant iron values and concomitantly deviant vitamin content in ascending order of vitamin C values | | | | | |
| India | CSB | 0.0 | 96.0 | 3.3 | 8.6 |
| India | CSB | 0.0 | 97.0 | 3.7 | 8.9 |
| Philippines | CSB | 0.0 | 260.0 | 3.9 | 8.5 |
| India | CSB | 3.0 | 273.0 | 5.8 | 7.9 |
| India | CSB | 9.7 | 344.0 | 9.8 | 7.2 |
| Ethiopia | CSB | 17.1 | 603.0 | 4.5 | 10.0 |
| India | CSB | 19.1 | 975.0 | 7.1 | 7.8 |
| Ethiopia | CSB | 20.0 | 556.0 | 8.4 | 9.0 |
| India | CSB | 22.8 | 1013.0 | 10.6 | 7.9 |
| India | CSB | 270.0 | 4948.0 | 45.7 | 6.6 |
| Samples with expected iron values but concomitantly deviant vitamin content from ascending order of vitamin C values | | | | | |
| India | CSB | 0 9 | 162.0 | 15.7 | 9.1 |
| Ghana | WSB | 4.2 | 235.0 | 22.0 | 7.4 |
| Philippines | CSB | 17.0 | 446.0 | 22.3 | 9.8 |
| India | CSB | 69.2 | 742.0 | 31.6 | 8.7 |
| India | CSB | 61.4 | 3601.0 | 22.4 | 8.2 |
| India | CSB | 77.3 | 3537.0 | 18.2 | 8.8 |

Source: USAID/Office of Nutrition, 1994

The remaining 20 of the 36 samples (Table 3.6b) showed much less variability and had an average of 34.5mg of vitamin C/100g or 86 percent of the amount added, and an average of 1688IU of vitamin A/100g or 73 percent of the 2314IU/100g originally added. The moisture content on these 20 samples averaged 8.4 percent and the average iron content was 20.8mg iron/100g. These calculated losses for vitamins A and C are more in line with what would be expected in products fortified with stabilized forms of these vitamins. The data strongly indicate that there is a major problem of accurate blending and mixing of both the vitamin and mineral premixes at the mill level. Because of considerable variation in micronutrient levels from bag to bag of the same blended food supplement it is difficult to determine the extent of vitamin losses.

**Table 3.6(b):**
**Vitamin A, Vitamin C, and Iron Content in Field Samples of Corn Soy Blend (CSB) and Wheat Soy Blend (WSB)**
**(cont. from Table 3.6[a])**

| Country | Sample | Quantities in 100g of Commodity | | | Moisture (%) |
|---|---|---|---|---|---|
| | | Vitamin C (mg) | Vitamin A (IU) | Iron (mg) | |
| Twenty of thirty remaining after those without concomitantly deviant values were removed (shown in Table 36.a), in ascending order of vitamin C values. | | | | | |
| Ghana | WSB | 8.7 | 1761 | 20.8 | 9.0 |
| India | CSB | 19.5 | 1035 | 16.4 | 7.5 |
| Guatemala | CSB | 22.8 | 1091 | 21.9 | 8.9 |
| India | CSB | 22.9 | 1012 | 19.1 | 9.1 |
| Ghana | WSB | 24.5 | 933 | 24.1 | 8.1 |
| India | CSB | 27.1 | 1260 | 22.0 | 8.3 |
| Guatemala | CSB | 28.2 | 1014 | 26.8 | 8.9 |
| Nicaragua | WSB | 33.0 | 1713 | 18.5 | 8.3 |
| Philippines | CSB | 34.2 | 375 | 25.2 | 9.5 |
| Nicaragua | WSB | 36.7 | 1775 | 22.8 | 8.2 |
| Nicaragua | WSB | 37.5 | 1700 | 19.5 | 8.0 |
| Nicaragua | WSB | 38.1 | 2509 | 23.7 | 8.6 |
| Nicaragua | WSB | 40.7 | 2441 | 22.5 | 8.9 |
| Nicaragua | WSB | 42.1 | 3241 | 21.8 | 9.1 |
| India | CSB | 42.7 | 2109 | 19.4 | 7 4 |
| Mauritania | WSB | 44.0 | 1112 | 19.0 | 7.7 |
| India | CSB | 44.4 | 2185 | 20.6 | 7.8 |
| India | CSB | 46.2 | 2785 | 14.6 | 9.3 |
| India | CSB | 46.6 | 2006 | 19.2 | 8.4 |
| India | CSB | 49.9 | 1782 | 17.6 | 7.6 |
| Averages (N=20) | | 34.5 | 1688 | 20.8 | 8.4 |
| % of specification estimate | | 86% | 73% | 100% | |
| Specification estimate | CSB | 40 | 2314 | 18.0 | |
| | WSB | 40 | 2314 | 20.2 | |

Source: USAID/Office of Nutrition, 1994

Cort et al. (1976) reported that 33 percent of the vitamin A added to cornmeal was lost after 12 weeks of storage at 45°C. Bookwalter et al. (1980) observed a 20 percent loss in vitamin A activity when a blend of cornmeal, soy flour, and non-fat dry skim milk was stored at 43°C for 2 months. Similarly, losses of 20 percent of vitamin A were noted by Rubin et al. (1977) during storage of corn grits and cornmeal fortified with vitamin A.

In an unpublished study conducted in India, a high degree of variability also was observed in vitamin A content of CSB sampled at different points in the food delivery system (Atwood et al., 1994), with values ranging 10-fold from 200 to 2000mcg/100g as compared with an expected level of approximately 600mcg. The marked variability of the vitamin A content of CSB within bags confounded the interpretation of results on the stability of vitamin A since much of the differences noted could have been the result of inadequate addition and/or blending of the vitamin premix. Group averages, however, indicated that losses of approximately 30 to 45 percent may have occurred during the 4 to 6 month period.

Additional information is needed on the stability of both vitamins A and C in properly blended food supplements that have comparable levels of these fortificants at the beginning of the study.

### C.3. Stability of Vitamin A in Vegetable Oil and WSB

Favaro et al. (1991) found that all-trans retinyl palmitate added to refined soybean oil remained stable during commonly-used storage and cooking practices and concluded that fortification of vegetable oil with vitamin A is feasible for use in Brazil. When stored at room temperature (23°C) in sealed containers protected from light, 99 percent of the vitamin A was retained for 9 months; after 18 months 41 percent of the added vitamin A still remained. Even in open containers, kept in the dark, the vitamin A was stable for 6 months, after which it gradually deteriorated. The vitamin A retained in cooked rice was 99 percent. Eighty eight percent of the vitamin A in cooking oil was retained in beans boiled for 90 minutes and 58 percent of the vitamin A remained after repeated frying of potatoes in the same oil. Later studies confirmed these findings and showed that the biological activity of vitamin A thus treated, as measured in rats, was not altered (Favaro et al., 1992).

Recently (Dutra de Olivera, et al., in press) demonstrated that vitamin A in the form of all-trans retinyl palmitate added to soybean oil is well absorbed in humans, as measured by the post-absorptive peak rise in plasma vitamin A, even during and after cooking. Thus, it can be concluded that vitamin A fortified soybean oil is well utilized by humans and that it can be an important vehicle for provision of vitamin A in populations where vitamin A deficiency is commonly prevalent.

A study in India on vitamin A stability indicated that vegetable oil sealed in metal containers had a high retention of vitamin A over a five-month period under conditions of high temperature and humidity (Atwood et al.,1994). The vegetable oil, refined and partially hydrogenated soy or other vegetable oil, was fortified with all-trans retinyl palmitate and contained antioxidants (BHA and BHT). The concentration of the stored oil was 491mcg/10g equivalent to the daily ration for each child. These results indicate that P.L. 480 vegetable oils may be suitable for vitamin A fortification.

## D. Quality Assurance of Fortification

Current quality assurance measures put in place by USDA for the production of P.L. 480 Title II commodities include on-site inspection and sampling by the USDA/FGIS for every production run. Samples are taken from each lot at the production site for proximate analyses (ash, protein, total carbohydrate, fiber, and fat) and moisture content. For those commodities enriched with iron, samples are also tested for the presence of iron by a qualitative assay procedure. The test for iron is used as an indicator that the mineral or enrichment mix has been added to the final product. Although

individual specifications for commodities fortified with vitamin A include provisions for sampling and analyses of vitamin A levels, no quality assurance assays for vitamins are currently being practiced.

Currently, there is no regular program of quality assurance of micronutrients in P.L. 480 commodities. It is recognized by the USDA that a quality assurance program is needed for micronutrients in P.L. 480 commodities. Plans to initiate procedures for quality control of micronutrients added to P.L. 480 commodities have been discussed. The procedures may include a review of options for monitoring fortification and enrichment levels within the current program with an effort to keep additional costs of the overall program at a minimum. Proposals being discussed by USDA include random sampling by FGIS of selected fortified commodities for analyses of vitamin A and iron by private certified laboratories. If vitamin A or iron levels are not within the specified levels, the manufacturers of the blended processed foods would be required to provide USDA with analytical data at their expense to certify that acceptable levels are present. In addition, manufacturers of the vitamin and mineral premixes will be required to provide data to USDA to verify nutrient levels in their premix products, although frequent verification is not considered to be necessary.

# IV. RECOMMENDATIONS FOR IMPROVING MICRONUTRIENT QUALITY OF P.L. 480 TITLE II COMMODITIES

The limited data on the quantities of specific commodities consumed by target groups (i.e., young children, pregnant women, school children, and refugees and displaced people) and the quantities and types of other foods available to them, make it difficult to quantitatively evaluate the requirements for micronutrient fortification. Assumptions of food uses and intakes are based largely on discussions with PVOs, food use reports by country, and recommendations made for ration selection in the Commodities Reference Guide, USAID, 1988, and Draft Supplement on Emergency Rations (USAID, 1988; USAID, 1993c) as well as assumptions made in previous technical reviews.

Recommendations follow, for which implementation will be dependent on management feasibility. Those recommendations which have no apparent technical or managerial constraints to implementation are identified as "short-term." Those which will have additional research contingencies or require minor managerial consultation with other stakeholders are identified as "medium-term." Those that will require more comprehensive research, negotiations and dialogue with a wide range of stake holders (e.g., USDA, industry, cooperating sponsors, the World Food Program, and USAID bureaus and missions) are marked as "long-term."

## A. Fortification and Enrichment of P.L. 480 Commodities to Improve Micronutrient Availability to Targeted Groups

### A.1. Recommendations for Improving Fortification of Blended Foods

#### A.1.1 Improve Iron Availability

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|---|---|
| A.1.1(1). | Recommendation: Increase ferrous fumarate by 50 percent in blended food supplements, if Stability, Odor and Taste Tests are positive. (Medium-term) |

A 1990 Technical Committee Report on Iron and Vitamin C, recommended the iron fortification of blended food supplements be doubled to supply 30mg instead of the current 15mg of added iron/100g of food. This has not been implemented because of subsequent concerns about potential excessive intakes, adverse effects on the foods caused by oxidation, and iron loading in some individuals, and concern over organoleptic effects.

Given current understanding of iron absorption from various diets (DeMayer, 1989) children between the ages of one to three would absorb approximately 0.48mg from 16.1mg of total iron ingested, if the diet consists of 75g of CSB (containing 15mg of iron from ferrous fumarate/100g) and 10g of vegetable oil with rice or corn contributing the remaining energy to meet energy needs. This assumes that only 3 percent of the ingested iron is absorbed. This level of absorbed iron is about 72 percent of the extrapolated requirement of 0.67mg of absorbed iron based on recommendations of FAO/WHO (1988). Increasing the ferrous fumarate by 50 percent to supply 22.5mg iron/100g of CSB, rather than the current 15mg of iron/100g, would increase the absorbable iron level to 0.65mg or 97 percent of the requirement for the 1-3 year old child, given the same assumptions. Further

increases are not considered necessary or desirable at this time. Research related to this recommendation is listed in Section V.

Consumption data are difficult to obtain for blended food supplements, but it is unlikely that a child or a pregnant woman would consume more than 200 and 300g of CSB, respectively. These amounts of CSB would contain 45 and 67.5mg of iron from ferrous fumarate, respectively, if the amount of ferrous fumarate is increased by 50 percent. Calculations also have been made assuming that pregnant women consume 150g of CSB (with 22.5mg iron from ferrous fumarate/100g) daily along with cereal grains (rice or corn) and 20g oil to meet their energy needs (Table 3.1). Such diets would contain approximately 42mg iron, 34mg of which would be supplied by the added ferrous fumarate and 8mg/100g supplied naturally by the food. It has also been assumed that 5 percent of the total iron will be absorbed. Although this level of absorption is higher than that assumed for the young child, it is still a low level of uptake by iron deficient subjects in terms of complete diets. This total diet would provide 2.1mg of absorbable iron, or 58 percent of the suggested requirement (3.6mg) of absorbable iron (DeMayer, 1989). When the iron stores of pregnant women have been depleted, their iron needs usually cannot be met entirely through dietary sources including fortification (NRC/NAS, 1979). Iron supplements will continue to be needed during the second and third trimesters of pregnancy.

Currently, 0.46kg of ferrous fumarate is used per MT of blended food, at a cost of $2.80/kg. Hence the current cost of the fortificant, ferrous fumarate, is $1.29/MT of blended food. A 50 percent increase would add about $0.645/MT to the cost of fortifying the blended foods. In 1993, 315,267MT of blended foods were used, yielding a total cost increase of $203,347 for this option to increase ferrous fumarate.

### A.1.2 Other Micronutrients

From the limited calculations of nutritional adequacy of cereal-based diets containing CSB, vegetable oil, and the predominant cereal grains for the one to three year old child and pregnant woman, presented in Tables 3.1 and 3.2, the following options are suggested for improving the availability of other micronutrients.

In the premixes used to make blended foods, the levels of zinc, riboflavin, and iron are low and the level of vitamin B-12 is high. In addition, the levels of calcium and phosphorus appear higher than needed for nutritional purposes. The low level of vitamin D is not considered a problem in most countries because exposure to sunlight is likely to cause sufficient synthesis of vitamin D in the skin. In countries where children are swaddled as in the Near East, the vitamin D level in the vitamin premix could be increased two to three-fold to prevent the potential development of rickets. This, however, would require the development of country or culture-specific formulations of commodities.

Folic acid levels exceed recommended levels. However, it is not recommended to reduce levels of folic acid in view of the importance of adequate folic acid intake for women of child-bearing age and of recent interest in the possible value of high intakes at onset of pregnancy in preventing neural tube defects. The levels of all other added nutrients in the supplement appear to be satisfactory, based on the model diets presented in Tables 3.1 and 3.2.

A.1.2(1). Recommendation: Reduce vitamin B-12 levels in blended food supplements by approximately two-thirds. (Short-term)

The vitamin B-12 content of the blended food supplements could be safely reduced by approximately two-thirds, from 40mg to 13mg/MT (3.97mcg to 1.3mcg/100g). This level would provide 0.65mcg of vitamin B-12 per 75g of CSB, the estimated ration used for the 1 to 3 year old child, which will provide approximately 130 percent of a child's allowance. For the pregnant woman consuming 150g of CSB, 1.95mcg of vitamin B-12 would provide approximately 139 percent of her estimated allowance. Vitamin B-12 costs about $11/g. At the current level of fortification (40mg/MT) the cost is $0.40/MT. Reducing the amount of B-12 to 13mg/MT would save $0.27/MT, and using the 1993 tonnage, the savings would be about $85,119.

A.1.2(2). Recommendation: Increase levels of riboflavin by approximately 114 percent (3.9g to 8.2g/MT) in blended foods. (Short-term)

The levels of riboflavin in blended foods should be more than doubled in order to achieve adequate levels of intake by both the 1 to 3 year old child and by the pregnant woman. This is especially important for populations subsisting on rice- or corn-based diets supplemented with blended foods as indicated in Tables 3.1 and 3.2. If the level of riboflavin is increased from the current level of 3.9g to 8.2g/MT (0.39mg to 0.82mg/100g), the riboflavin intakes would just meet the recommended allowances, based on consumption levels suggested in Tables 3.1 and 3.2. With riboflavin costing about $70/kg, fortification at the current level of 3.9g/MT costs about $0.27/MT. Elevating the amount of riboflavin to 8.2g/MT will cost about $0.57/MT, an increase of $0.30/MT. This option would increase the cost of blended commodities by about $94,600 based on 1993 tonnage.

A.1.2(3). Recommendation: Increase level of added zinc ten-fold and change the form of zinc used in blended commodities. (Short-term)

The zinc levels in corn- and rice-based diets assumed in Tables 3.1 and 3.2 are very low for both the 1 to 3 year-old child and the pregnant woman, ranging from 33 percent to 54 percent of the NRC 1989 recommended dietary allowances. The level of zinc sulfate hydrated ($ZnSO_4.7H_2O$) should be increased from the current level of 39g to 390g/MT of blended foods. This would provide 93 percent and 123 percent of the zinc allowances for the young child and pregnant woman, respectively, on a corn-based diet. Even in wheat diets, which contain higher levels, much of the zinc is not bioavailable. The cost of 39g of the zinc sulfate is about $0.16, a ten-fold increase will cost $1.60/MT. Based on 1993 tonnage of blended foods distributed, implementation of this option would increase the cost of blended foods by about $454,000.

The source of zinc should be changed from the hepta-hydrate to the mono-hydrate form of zinc sulfate. The mono-hydrate zinc sulfate (37 percent zinc) is less expensive and more stable than the hepta-hydrate zinc sulfate (23 percent zinc). The current zinc requirement in blended foods would be accomplished with 24g/MT using mono-hydrate zinc sulfate at a cost of $0.11/MT, a ten-fold increase in zinc would increase the cost with this form of zinc (relative to current costs) by about $300,000.

A.1.2(4). Recommendation: Maintain current level of vitamin C fortification. (No Change)

Vitamin C is unstable and actual amounts consumed by food aid recipients are unknown. Based on assumed diets, more than adequate amounts of vitamin C would be provided. However, large losses in vitamin C would be expected to occur during storage, handling, distribution and cooking of the commodities. Studies need to be conducted to measure vitamin C being consumed by food aid recipients.

### A.1.3 Calcium and Phosphorus

A.1.3. Recommendation: Reduce by approximately 25 percent the fortification level of calcium and phosphorus in blended foods, if studies confirm that nutritional, anti-caking, and insect suppressant properties of TCP can be retained. (Medium-term)

Both CSB and WSB contain 2 percent anhydrous tricalcium phosphate (TCP) as the source of calcium and phosphorus. The use of TCP is based largely on its insect suppressant and anti-caking characteristics in these blended products. A review of the total calcium and phosphorus content of the diets presented in Tables 3.1 and 3.2 demonstrate that in all cases the phosphorus and calcium intakes of both the one to three year old child and the pregnant woman exceed their nutritional needs.

The level of TCP used in the mineral premix for blended foods can safely be reduced for nutritional purposes from 20 to 15kg/MT of final product. Ground corn or wheat should be used to replace 5kg of TCP/MT. This level would supply 580mg calcium and 300mg of phosphorus per 100g of the blended food supplements. These levels would be in addition to that present in the grains and the soy flour and would be adequate.

Other sources of food grade calcium and phosphorus should also be considered such as calcium carbonate, calcium sulfate, and potassium phosphate. Considering that TCP serves as a desiccant in the product which accounts for anti-caking, anti-microbial, and anti-insect properties, evaluations of its reduction and substitution with other substances with similar properties need to be

conducted. It is important that the nutritional quality as well as insect suppressant and anti-caking properties are maintained. Maintenance of reduced moisture levels (recommendation A.1.4) may accomplish similar effects as TCP.

It is estimated that the TCP in the blended foods currently costs $30/MT of food based at the specified concentration of 2 percent (20kg/MT) with TCP costing $1.50/kg. Reducing the amount of TCP by 5kg/MT would save about $7.50/MT. Based on 1993 tonnage of blended foods distributed, the savings would be about $2.4 million. Alternative sources of calcium and phosphorous should be evaluated for use in blended foods since additional savings might be possible by further reductions or the elimination of TCP.

### A.1.4 Reduce Moisture Levels in CSB and WSB

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| A.1.4. | Recommendation: Keep moisture of blended commodities at 8.5 percent or less. (Long-term) |

Current USDA specifications for CSB indicate that moisture content should not exceed 10 percent. Analysis of samples taken by USDA from CSB made by three different suppliers, revealed some low moisture levels, 7.07, 7.92, and 8.17 percent. Similar data for WSB show that 10 samples out of 16 contained less than 8 percent moisture, with one value of 6.97 percent. Therefore, low moisture content in blended food commodities can be accomplished.

The moisture level of the blended food supplements should be kept as low as practical in order to minimize vitamin C losses and other adverse effects. Vitamin C, if present in food when eaten, tends to improve the absorption of dietary iron. Also, maintenance of low moisture content would reduce the requirement moisture absorption by TCP. The economic consideration for moisture content is particularly important since commodities are purchased and shipped on the basis of weight. It is recommended that costs of reducing and maintaining moisture levels to 8.5 percent be determined, and consideration be given to reducing the level of moisture in the specifications. Based on the cost of drying rice, it is estimated that the cost of reducing moisture content from 10 to 8.5% would be less than $0.83/MT. However, detailed examination of the costs and benefits of this recommendation needs to be conducted.

## A.2. Fortification of Vegetable Oil with Vitamin A

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|---|---|
| A.2.1. | Recommendation: Consider fortifying vegetable oil with vitamin A. (Long-term) |

Fortification of vegetable oil with vitamin A should be evaluated. The advantages of using vegetable oil as the vehicle for Vitamin A fortification include:

- Improved stability of vitamin A with prolonged storage.
- Less variability of vitamin A content and greater assurance of actual intakes.
- Probability of better absorption of vitamin A.
- Expected lower cost since a less expensive form of vitamin A could be used in oil than in premixes.

For oil, vitamin A palmitate or another suitable ester form with antioxidants can be used. The recommended level of fortification is approximately 450mcg or 1500IU of vitamin A per 10g of oil which is the current level of vitamin A fortification of oil being practiced by Sweden and Canada.

If this option is adopted, it may be desirable to offer vegetable oil and the blended foods both with and without vitamin A fortification to ensure particular needs of countries are being met. For example, in India, 10g of vegetable oil is mixed with the CSB in the Integrated Child Development Services (ICDS) feeding programs. In this program, it would probably be more effective to supply the vitamin A in the oil. In Ecuador, however it appears that oil is not consumed with the blended foods at MCH centers. In this case, the blended food should continue to be fortified with the present level of vitamin A. Vegetable oil destined for monetization programs should not be fortified with vitamin A since it is less likely to reach target beneficiaries.

USAID/BHR has expressed reservations about fortifying vegetable oil with vitamin A, and removing it from CSB, because of existing limitations on food aid programming, procurement, shipment and distribution, monitoring and control over end uses. USAID/BHR has indicated that tailoring of commodities would require considerable management control and monitoring. USAID also points out that under emergency response situations vegetable oil and CSB are sometimes diverted from their original destinations.

If several vitamin A fortified commodities are used in conjunction with vitamin A fortified oil or other vitamin A fortified products over an extended period, care should be taken to avoid accruing higher dietary levels than 10,000IU of vitamin A per day. Accordingly, it may be desirable to offer the protein fortified and 'enriched' foods in both vitamin A fortified and unfortified forms, if fortified vegetable oil is to be regularly used. These options indicate the need to tailor some commodities for specific uses.

Fortification of vegetable oil has been found to be more cost-effective than fortification of CSB in the ICDS India program (Atwood et al., 1994). Shipment losses were 35 percent for CSB

compared with 15 percent for oil. Vitamin A is less expensive for fortifying oil than for CSB because it is a fat-soluble, which is readily soluble and dispersed in oil, whereas converting it to powder for fortifying flour is more costly. The vitamin A fortificant for CSB costs about $0.17 per million IU, while that for vegetable oil costs $0.052 per million IU. The implied level of fortificant in their calculations was 0.08kg/MT for CSB, and 0.132kg/MT for oil. This yielded a cost of fortifying CSB of $3.36/MT, and for oil of $7.13/MT (representing in each case about one percent of the cost of the item). However, because only 10g of oil was needed to provide 400mcg of retinol, compared with a requirement of 65g of CSB to provide the same amount, the oil was the least expensive vehicle for delivering vitamin A.

In 1993, 282,739MT of CSB were programmed under Title II, of which 157,188MT were distributed via CARE to the ICDS program. In the same year 173,360MT of vegetable oil were distributed of which 21.4 percent went to monetization programs. Thus, the additional cost of fortifying 136,200MT of vegetable oil (excluding monetized oil) with vitamin A would be $1.06 million. This cost could be partially reduced by removing vitamin A from the 157,188MT of CSB supplied to the ICDS program, a savings of $0.53 million. Thus, the net cost of this option would be $0.53 million.

For most countries more information is needed on consumption patterns prior to removing vitamin A fortification from processed grains and blended foods. However, information is sufficient for the large ICDS program in India to recommend fortification of oil with vitamin A and discontinue fortification of CSB with vitamin A. The costs of fortification with vitamin A are relatively small, and the intervention ranks very high in cost-effectiveness (World Bank, 1993).

As mentioned, if vegetable oil is fortified with vitamin A, it may be desirable to offer the most widely used enriched processed foods with and without vitamin A fortification (2000IU/100g) to avoid higher than needed intakes and additional costs.

## A.3. Enrichment and Fortification of Processed Food Commodities

### A.3.1 Processed Foods, Other Than Rice

Although rice is classified as a processed commodity because it is milled, its characteristics remain more like a whole grain. Therefore, fortification of rice is considered in the Section on whole grain (IV.A.4).

All of the processed cereals except rice are fortified with vitamin A. Fortification of these commodities with vitamin A is important, especially when sufficient quantities of blended foods are unavailable. This seems to be the case in most instances, but the limited data available on commodity use does not permit a quantitative evaluation. Vitamin A fortification of vegetable oil would help to provide sufficient vitamin A to populations that primarily consume processed cereals.

Iron and B-complex vitamins (thiamine, riboflavin, and niacin) are added at "enrichment" levels, which provide an important role, especially in supplying these nutrients to school-age children and pregnant women. However, requirements of adding iron and B-vitamins to wheat flour are not in the current USDA specifications. The failure to enrich wheat flour with iron and B-vitamins should be corrected. Wheat flour is a major P.L. 480 commodity providing 37 percent of the amount of processed cereals and soy-fortified cereals in 1993 and its enrichment should be improved.

A.3.1(1). Recommendation: Enrich wheat flour with iron and B-vitamins. (Short-term)

The recommendation is made to include iron and B-vitamins in the specifications for enriching wheat flour. The levels of iron and B-vitamins in wheat flour should be the same as for the other processed cereals. The cost of enriching wheat flour is estimated to be $0.72/MT and based on 1993 metric tons (270,003) the total cost would be $194,402.

A.3.1(2). Recommendation: Use ferrous fumarate instead of hydrogen reduced iron as the enrichment and fortification source of iron in processed foods. (Short-term)

Use of ferrous fumarate will provide more absorbable iron than from doubling the level of hydrogen reduced iron. This option also would be satisfactory for cornmeal as well as for other processed foods. It is suggested that 5mg of iron/100g from ferrous fumarate be used per 100g of food.

Costs associated with using ferrous fumarate instead of reduced iron for enrichment purposes have been estimated. Currently, using the minimum standard of 28mg iron/kg of food, i.e., 0.028kg iron/MT, and a price of reduced iron of $2.45/kg of iron, the cost of iron fortification is $0.07/MT. If, instead, ferrous fumarate ($8.48/kg of iron) were used, the cost would be $0.24/MT. In 1993, 518,100MT of processed commodities were used in P.L. 480 Title II programs. The increase in cost from fortification with ferrous fumarate instead of reduced iron would have been $110,000. Part of this increase in cost ($20,000) is attributed to adding ferrous fumarate to wheat flour which is currently not enriched with any sources of iron.

## A.4. Fortification of Whole Grains and Milled Rice

A.4.1. Recommendation: Whole grains and milled rice should not be enriched or fortified for P.L. 480 Title II programs. (Short-term)

Most whole grains distributed through Title II are used for FFW programs and emergency feeding or are monetized. Whole grains provided for FFW programs may be consumed directly by families, thereby reducing the need to buy other foods; or the whole grains may be sold, thus allowing the worker to purchase other food items, if desired. Since FFW programs are directed at households and not at individuals at high risk of nutritional deficiency, it is difficult for USAID to

justify the fortification of grains used in such programs. In principle, the grains used in FFW programs add to the total food supply of the country, and allow for income transfer and strengthening the food security of low income households, but it does not constitute a targeted approach to reach those at high nutritional risk, as do MCH and SF programs. Since emergency feeding, FFW, and monetization programs account for most of the whole grains used under Title II (78% in 1993), fortification of whole grains with a micronutrient mix, such as iron and B-complex vitamins, is questionable even if it could be done effectively.

Whole grains are usually milled prior to consumption. The milling process removes the seed coat and endosperm (germ) which contains micronutrients and inhibitors to micronutrient absorption. Inexpensive fortification of whole grains can be accomplished by coating micronutrients onto the whole grain; however, milling would remove these along with the naturally occurring nutrients. More expensive technologies are available which infiltrate the micronutrients or which form extruded analogs, although neither are commercially available. The fortification of whole wheat or corn with micronutrients would be practical if the whole grain was used, i.e., whole wheat flour. Rinse-proof coatings can be used to prevent the nutrients from being lost if the grains are washed. This technology is presently used for milled rice.

USDA (Crowley et al., 1989) in their final report of the food technology development project reported on a procedure for the coating of wheat grains with a 'white' vitamin A preparation. The vitamin A was shown to be heat-stable. The Wright Enrichment Co. of Crowley, La. produced a premix of vitamin A coated wheat grains, termed Vitamin A Wheat Concentrate for a study in Bangladesh. Iowa State University researchers also studied a similar vitamin A coated rice, which was prepared in small quantities by the Wright Enrichment Co., but vitamin A in the enriched rice product failed to have adequate cooking resistance or storage ability. Since these studies, advancements have been made in the ability to apply the hydrophobic vitamin A to whole grains. However, further testing is required prior to use in fortifying P.L. 480 whole grains.

More interest has been raised in the enrichment of rice. Most milled rice marketed in the USA is enriched with niacin, thiamin, and iron. Riboflavin is required for enrichment, however, it is not currently used because it discolors the rice. Iron is added in the form of ferric orthophosphate which has the advantage of white color but the disadvantage of poor bioavailability. Presently folic acid is being considered for enriching milled rice. In practice, a premix is added to the rice with some agent to make it stick to the outer surface of the rice grains. Powdered micronutrients blended with rice will be removed during washing. To prevent losses due to rinsing, rinse-proof micronutrient-dense coated rice grains are manufactured for the enrichment of milled rice. The fortified rice is blended with unfortified rice. This process is slightly more expensive than powdered coatings.

A more expensive technology involves adding enriched synthetic "grains" of rice with added vitamin A (extruded from rice flour), to unenriched rice. The micronutrients in synthetic grains are not removed by washing. The extruded synthetic rice has only been fortified with vitamin A and no trials have been conducted with fortification of other micronutrients. Using this technique for fortifying rice with micronutrients that are colored such as iron and riboflavin would be a problem since the micronutrient-dense grains would look different than normal rice and might be rejected by the consumer.

## B. Fortification for Special Needs and By Recipients

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|---|---|
| B.1.1. | Recommendation: Consider local fortification and enrichment in special circumstances under carefully controlled conditions. (Long-term) |

Whole grains can be shipped in bulk whereas milled flour or meals require more costly packaging and have reduced storage-life. If central milling is done, then enrichment or fortification of the flour or meal can be considered if there is a need and an appropriate basis for national fortification. Given the needs of a particular country, USAID should consider ways to encourage local enrichment and/or fortification in the country. This should be part of a country's overall food and nutrition strategy.

If whole grains are provided to displaced people or refugees under emergency situations central milling is seldom an option; nor is the appropriate equipment or quality control likely to be available for milling and/or fortifying foods locally. Under some dire circumstances, substitute mixing equipment (cement mixers) have been used to add fortificants, but such approaches cannot provide long-term solutions, and they can have severe repercussions because of the lack of sanitation, contamination, and overall safety as well as uneven mixing. Only if centralized milling is available can in-country fortification and enrichment be considered an option to solve micronutrient deficiency problems. Uniform mixing of premixes with milled commodities is difficult to accomplish even with the most advanced equipment technologies available. Therefore, only in very special circumstances should on-site fortification of P.L. 480 commodities be considered. As food technology becomes more common in developing countries, this option may become more feasible and should, therefore, be reconsidered periodically.

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|---|---|
| B.1.2. | Recommendation: Utilize existing fortified blended food supplements in emergency situations. (Medium-term) |

In emergency feeding situations where whole grains are likely to be used because of their lower costs, suitable fortified food(s) or appropriate supplements are needed to prevent micronutrient deficiencies including scurvy, pellagra, and anemia. Rather than fortify whole grains to meet this problem, local agencies should be encouraged to use presently available blended and/or enriched commodities along with locally available foods to provide the limiting nutrients, or pharmaceutical supplements must be made available. The increased levels of micronutrients provided by adding 40g of CSB to a corn-based ration are given in Table 4.1. It is critical that dietary and nutritional status assessments are conducted in emergency programs to establish appropriate commodity provisions in order to prevent micronutrient deficiencies.

**Table 4.1:**
**Estimated Micronutrient Adequacy of Corn-Based Ration with Corn Soy Blend (CSB) Supplement**

| | | Percent of Allowances Provided | |
|---|---|---|---|
| Nutrient | Allowances [1] | Corn-based ration [2] | Corn-based ration and 40g CSB [3] |
| Energy (Kcal) | 2200 (a) | 92 | 92 |
| Protein (g) | 50 (a) | 123 | 129 |
| Calcium (mg) | 500 (b) | 21 | 85 |
| Phosphorus (mg) | 500 (c) | 239 | 258 |
| Iron (mg) | 23 | 68 | 91 |
| Zinc (mg) | 15 (d) | 76 | 72 |
| Vitamin A (IU) | 2000 | 93 | 144 |
| Vitamin D (IU) | 800 (d) | NA | 10 |
| Vitamin E (mg) | 10 (d) | NA | 35 |
| Vitamin C (mg) | 30 (a) | 15 | 66 |
| Thiamine (mg) | 1.2 (b) | 175 | 192 |
| Riboflavin (mg) | 1.8 (b) | 60 | 64 |
| Niacin (mg) | 19.8 (b) | 87 | 89 |
| Pantothen. acid (mg) | 4 - 7 (d) | 59 | 63 |
| Pyridoxine (mg) | 2.0 (d) | 28 | 145 |
| Folic acid (mcg) | 200 | 152 | 186 |
| Vitamin B-12 (mcg) | 1.0 | 0 | 158 |
| Iodine (mcg) | 150 (d) | NA | 33 |

[1] FAO/WHO (1988) unless otherwise noted
[2] Monthly ration. 13.5kg corn, 1.8kg beans, 0 6kg veg oil World Vision (personal communication), June 1994
[3] Same as (2), with 40g CSB replacing equivalent energy amount of corn
(a) USAID/BHR, 1993, Draft Supplement on Emergency Rations for the Commodities Reference Guide.
(b) FAO, 1974
(c) Assumed 1.1 ratio for calcium and phosphorus
(d) NRC/NAS, 1989
NA - Nutritional data not available

Although USAID cannot ensure optimal use of fortified blended foods in all emergency situations, over time it can encourage and promote more adequate diets composed of locally available foods, food aid, and pharmaceutical supplements, if necessary, to address micronutrient needs. U.S.-based and international organizations often assess and plan diets using a combination of U.S. and other donor assistance which are not completely under USAID's control.

## C. Improve Quality Control Measures

C.1. Recommendation: Establish quality control program for ensuring micronutrient content of P.L. 480 Title II commodities. (Medium-term)

As discussed in Section III, there are large variations in the micronutrient levels of fortified and enriched foods at the site of manufacturing. Discussions with ASCS/USDA indicated that plans are being made at USDA to establish a quality control mechanism to assure that added levels of micronutrient in fortified and enriched commodities are within the required specifications before shipment. USDA recognizes that a quality assurance system needs to be devised to verify levels of fortification and enrichment in commodities produced by various manufacturers. If products do not meet current specifications, manufacturers will be required to provide additional analyses to verify nutrient content.

Measures to evaluate the quality and content of micronutrients in fortified foods through the distribution systems and after local preparation are also proposed. These measures could be instituted on a pilot basis and should include a mechanism to ascertain the losses of selected nutrients (vitamin A and C) due to handling/storage and also cooking under local conditions. To maintain the necessary control of this information by USAID, commodity samples could be obtained from PVOs and sent to certified laboratories in the United States for analysis and reporting of results to USAID. Periodic monitoring would provide information on nutrient stability under given time periods and handling conditions. The information should identify any further improvements needed to ensure adequate micronutrient content in P.L. 480 commodities. Field assessments or estimations of impact on recipients will be hampered unless a quality control program is in place to ensure fortification and enrichment levels prior to shipment.

Costs should be determined for establishing and maintaining such a quality control program for micronutrients in P.L. 480 Title II commodities. Such a system should become a regular component of the P.L. 480 program.

## D. Strengthen Technical Advisory Involvement

D.1. Recommendation: Strengthen USAID technical committee participation in and oversight of fortification and enrichment practices. (Short-term)

Technical oversight of the nutrient specifications of Title II P.L. 480 commodities is currently provided by the USAID Joint Committee on Nutrition Specifications of Food Aid Commodities. Participation by representatives of the agricultural/food technology/nutrition research community is essential to properly carry out the mandate of the Committee. The Committee should be restructured, if necessary, to play a more active and influential role in providing technical information and

direction. The Committee should assist with providing technical information to be used as the basis for making decisions to improve the nutritional quality of Title II P.L. 480 commodities.

D.2. Recommendation: Promote development of international standards for micronutrient fortification and enrichment practices. (Medium-term)

There are large differences in micronutrient fortification and enrichment practices between countries providing food aid. Without uniformity in micronutrient levels of foods, the dietary requirements or recipients are difficult to satisfy. An Expert Panel convened by FAO/WHO could assist with developing uniform International Standards for micronutrients in food aid commodities.

D.3. Recommendation: Establish a mechanism to investigate micronutrient problems at the field level to assure proper use of P.L. 480 Title II commodities. (Medium-term)

The 1988 USAID Technical Review Panel on Vitamin A recognized that the data-base for making recommendations for fortification levels needed to be strengthened. It stated the need for better data on program usage and on the median and range of actual individual intakes of commodities in both regular and emergency programs. The Panel strongly urged USAID to establish a mechanism to collect such data. Work by the present USAID Committee could be strengthened by establishing a mechanism whereby relevant information on the actual needs in the field and uses of the various commodities could be regularly reviewed to better evaluate the current adequacy of fortification levels. PVOs could contribute to such investigations. In addition, program commodity use data from USAID/BHR and technical input from Office of Nutrition should be readily available to better evaluate the appropriateness of various fortified and enriched commodities for different program uses. A quality control program to ensure micronutrient levels in commodities prior to shipment will be essential for meaningful field investigations.

D.4. Recommendation: Maintain overview of commodity allocation by region, so as to best target fortified and enriched foods to needy households; provide more explicit guidance on regional programming of commodities. (Long-term)

There are few formal guidelines for the allocation of particular commodities by region and by program, and to some extent the PVOs make the decision as to what to request. Data in Tables 2.5 and 2.6 indicate that it would be useful to have some overview on commodity allocation by region and program so as to assist with targeting more nutritious foods to more needy households. Although households in the richer countries may be more accustomed to receiving and consuming the more

expensive items, this does not necessarily imply that they should receive a proportionately higher share of these items from aid sources.

Likewise, it might be useful to have more explicit guidelines for the different programs. In 1993, for example, $5.9 million worth of blended foods went to FFW programs, where they are relatively less likely to reach the group for whom the blended foods were designed (pregnant and lactating women and preschool children). Similarly, $14.1 million of soy-fortified commodities went to FFW programs. An examination of the detailed commodity data provided by the Food for Peace Office indicates that an NGO operating three types of programs, e.g., MCH, SF, and FFW in the same country often requests the same mix of commodities for each program for convenience in handling and administration. However, nutritionally and economically, it may not be appropriate to use blended foods and soy-fortified items for FFW programs. On a nutritional basis, FFW programs are more "income maintenance" and, therefore, less likely to reach specific high risk groups. On an economic basis, the blended foods and soy-fortified items are probably not highly cost-effective in FFW programs. (Ruetlinger and Katona-Apte, 1983; Fitzpatrick and Hansch, 1990.)

## V. RESEARCH AND INFORMATION NEEDS FOR IMPROVING MICRONUTRIENT FORTIFICATION OF P.L. 480 TITLE II COMMODITIES

### A. Iron

1) An experimental evaluation should be made for fortifying WSB with NaFeEDTA to supply 2mg of iron/100g to evaluate iron efficiency. The combination of iron from NaFeEDTA with the naturally occurring iron will give a molar ratio of EDTA to iron of 0.68:1 resulting in an estimated intake of 0.95mg of EDTA/kg body weight. It should be determined whether this low level of iron from EDTA improves the absorption of the relatively unavailable iron provided by the soy flour and wheat when 1-3 year old children consume approximately 75g of WSB in an otherwise cereal- and legume-based diet. The WSB has been selected for the study instead of CSB since both whole wheat and soy meal contain substances which inhibit iron absorption. It is in this type of diet that NaFeEDTA is likely to have its greatest value on iron absorption. If it proved suitable for use in WSB then it could be used in CSB.

   Even though provisional approval of NaFeEDTA has been given (WHO, 1993) for use in food fortification programs in populations where iron deficiency is endemic, the allowable dose of EDTA limits the amount of NaFeEDTA which can be fed to young children. The maximum acceptable daily intake (ADI) of 2.5mg of EDTA/kg body weight, which must not be exceeded, would be met if a 1 to 3 year old child, weighing 11kg, obtained 69 percent of the energy requirements from food items containing NaFeEDTA at a level providing 2mg iron/100g (15mg NaFeEDTA/100g).

2) The effect of dietary EDTA and ratio of EDTA to zinc on zinc uptake should be further studied, since zinc nutriture appears to be marginal in specific populations where diets are high in whole wheat. This information is especially critical in growing children before the widespread use of NaFeEDTA for fortification is implemented. The greatest health risk involved in using substances containing EDTA is the potential of causing zinc, and to a lesser extent, copper deficiencies.

3) The use of NaFeEDTA in lieu of hydrogen reduced iron for the enrichment of the soy-fortified foods and bulgur needs to be evaluated in pilot studies. Since cornmeal and refined wheat flour contain less phytates than do whole wheat flour, EDTA iron would give less improvement over either hydrogen reduced iron or ferrous fumarate iron. It is suggested that 15.4mg of NaFeEDTA/100g (2mg iron/100g) be used in the soy-fortified foods and bulgur.

   Again it is assumed that children are not likely to obtain more than 67 percent of their energy from the combined commodity sources, thus avoiding an intake of more than 2.5mg of EDTA/kg of body weight. Any future use of NaFeEDTA in fortification should have controls built into the program to ensure that this permitted level of EDTA intake is not exceeded. The Joint FAO/WHO Expert Committee on Food Additives, in their provisional approval of NaFeEDTA as a dietary supplement, emphasized that it be used under supervision.

4) Stability tests should be done with CSB containing 22.5mg of added iron from ferrous fumarate/100g (50 percent increase over current level) at elevated temperatures and for several months to ensure that no off-flavor or taste changes occur.

5) The Joint FAO/WHO Expert Committee on Food Additives (JECFA) directed that a) additional studies be done to assess the site of deposition of iron administered through the consumption of NaFeEDTA; and b) that research be done to assess the metabolic fate of sodium iron EDTA following long-term administration.

## B. Vitamin C

1) Improved forms of vitamin C, such as the new fat encapsulated and phosphorylated forms should be evaluated for their stability during storage and cooking, as compared with the presently used stabilized form. This can be important since vitamin C can improve the absorption of iron if both are present in the food when consumed.

2) Studies are needed to determine the extent to which vitamin C losses will be expected under usual conditions of storage and preparation of the blended foods. Such data could be obtained by a laboratory under simulated conditions in the USA.

## C. Calcium

1) The effect of different calcium and phosphate sources instead of tricalcium phosphate (TCP) in blended food supplements needs to be evaluated for their nutritional and functional properties. Suitable low cost replacement of TCP would have a large impact on reducing the expense of fortification of blended commodities.

## D. Moisture

1) The critical limits of moisture in blended foods, above which vitamin C loss, microbial spoilage, and other adverse quality changes increase during storage should be defined. A mechanism to obtain information on moisture content of commodities during storage, handling, and distribution should be developed.

## E. International Standards for Enrichment and Fortification Levels

1) International standards are needed for enrichment and fortification of food aid commodities, for example, vitamin A levels in oil. This will allow for multiple sources of commodities to be used in combination to meet needs of target groups such as in emergency feeding of refugees or displaced persons. A request could be made to FAO/WHO for an Expert Panel to be convened to develop such standards. This would also assist commercial exporters who may wish to enrich their products, but who currently have no guidelines.

2) Additional studies are needed on the stability of vitamin A in fortified Title II commodities during storage and preparation.

## F. Specially Fortified Supplement for Displaced Persons and Refugees

1) Design and test under field conditions fortified food supplements for specific use in feeding displaced persons and refugee populations. This could be based on soy-fortified cornmeal with supplemental amounts of nutrients in whole grain diets. Fortification should include iron, vitamin A, thiamine, riboflavin, niacin, vitamin C, calcium, and vitamin B-12. Such a supplement should be formulated so that only about 30g is needed per person per day in order to reduce cost of packaging and shipment as compared to the use of a larger amount of CSB.

## G. Surveys and Assessments

1) Information should be collected and summarized by country on the amounts of Title II P.L. 480 commodities generally consumed, and the nature of the total diet, so that valid appraisals can be made of the micronutrient adequacy of diets for targeted population groups at high nutritional risk.

## H. Food-based Long-Term Approaches

1) Improvement in the nutritional qualities of whole grains through genetic modification and improved agricultural practices needs exploration for long-term food-based solutions. Based on explorative studies of the genetic factors that control the uptake of iron and zinc at root surfaces, existing variability of major food crops indicate that cultivars which produce grains with higher micronutrient density (especially iron, zinc, and carotenoids) can be readily selected if efforts are made in that direction (Graham and Welch, 1994). The ability of plant root surfaces to extract nutrients from soils varies greatly, and scientists are discovering the genes that control this process. Plants that have efficient genotypes and can extract adequate amounts of nutrients (especially zinc and iron) from deficient soils will have higher yields with greater micronutrient density. Low iron significantly affects yields and nutrient content of corn, sorghum, and upland rice, as well as cassava, beans and some vegetables grown on alkaline soils. Zinc uptake is frequently a problem in all major food crops.

   With methods now available for gene modification, the development of grains with higher levels of micronutrients better suited for feeding populations can be expected. USDA should be encouraged to pursue such research with the objective of developing markedly improved nutritional qualities of cereal grains which also addresses the constituents in these foods that may inhibit absorption of micronutrients.

## I. Identify Sustainable Food Aid and Fortification Needs for Food Security of Low-Income Families

1) A comprehensive analysis of the long-term food security needs of a developing country should provide the basis for determining the kinds and amounts of food aid commodities to best meet the food security needs of low-income families. With such information, the role of food enrichment and fortification as a sustainable approach to the solution of food and nutrition problems can be assessed. Not only should food aid be channeled so it fosters long-term development of agricultural (food production and processing) activities within the host countries, but, at the same time, it should enhance the food security and nutritional health patterns of low-income families. Better information on eating habits of food program participants and the effect of program foods on household expenditures should be obtained. Information is needed on the amounts and types of program food sold.

   Efforts should be strengthened to determine the extent that food assistance programs improves access to food in low-income families at high risk of nutritional deficiencies. Agency resources should be invested to obtain more information about the impact of specific food aid programs on food consumption practices of low income families and ways food assistance programs could be modified to enhance their long-term benefits.

## J. Further Identify Research Needs

1) The USAID Technical Committee established to oversee fortification and enrichment practices of P.L. 480 should establish priorities for information needs and research to continuously support improvements in the P.L. 480 Title II program.

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# ANNEXES

## ANNEX A(1):
## Scope of Work - P.L. 480 Title II Commodities - Technical Paper
## Food Technologist - Team Leader

Under the direction of an OMNI Core Staff member, the Food Technologist will work closely with the nutritionist and economist to write a technical review of current fortification practices of P.L. 480 commodities and to provide options for improving the program. The Food Technologist, as team leader, will be responsible for the following:

1. Provide leadership in identifying the topics and developing the structure for the technical report.

2. Assist with identifying and acquiring information important for the report, and coordination of meetings.

3. Review current materials, formulations, production, processing, and handling procedures (packaging, storage and transportation) of P.L. 480 commodities.

4. Review laboratory and field test results on stability of fortificants and fortified food commodities.

5. Review alternative materials, formulations, production, processing, and handling procedures for P.L. 480 commodities.

6. Address the advantages and disadvantages associated with alternative options of changing materials, formulations, production, processing, and handling procedures, including safety information.

7. Review quality control/assurance and monitoring practices currently used for existing and proposed fortified P.L. 480 commodities. Provide recommendations for improvement.

8. Provide assistance with establishing recommendations for maintaining or changing the types and levels of micronutrients, procedures, and monitoring systems.

9. Provide brief historical perspective to the report. Responsible for compiling information, reviewing, editing, and submitting a report in WordPerfect or equivalent software.

## ANNEX A(2):
## Scope of Work - P.L. 480 Title II Commodities - Technical Paper
## Nutritionist

Under the direction of an OMNI Core Staff member, the Nutritionist will work closely with the food technologist and economist to write a technical review paper examining the current fortification levels of P.L. 480 commodities and recommendations for improving the program. The Nutritionist will be responsible for the following:

1. Review current levels of micronutrients added to all P.L. 480 commodities in relation to the overall nutritional quality of the fortified commodities and the contribution of fortified food to the recommended daily intake.

2. Review published and unpublished (AID, NGO reports, etc.) literature on the adequacy of micronutrients in fortified foods in relation to their bioavailability and estimates of human nutrient needs at point of use.

3. Identify needs to improve the nutritional quality of P.L. 480 commodities.

4. Review options for improving the nutritional quality of commodities including associated safety considerations. Identify options to increase micronutrient levels, bioavailability, and design formulations for specific commodities (e.g., dried milk, flour, whole grain, oil), and populations or particular vulnerable groups (schoolchildren, supplementary feeding, general rations).

5. Consult with appropriate PVOs involved in P.L. 480 programs on (1) storage conditions and durations for P.L. 480 commodities and (2) the main dietary absorption inhibitors that are commonly consumed by large numbers of people (e.g., tea); dietary absorption enhancers that may be lacking in the diet (e.g., oil, citrus fruit); and likely excess loss of micronutrients through cooking (e.g., frying).

6. Draft report of findings, with recommendations for improving the nutritional quality of the commodities and estimate development and humanitarian benefits from an improved program.

## ANNEX A(3):
## Scope of Work - P.L. 480 Title II Commodities - Technical Paper
## Economist

Under the direction of an OMNI Core Staff member, the Economist will work closely with the food technologist and nutritionist to write a technical review paper examining the current fortification levels of P.L. 480 commodities and recommendations for improving the program.

The Economist will develop details for the planning of activities resulting from an economic analysis of USAID Title II food aid matrix in which fortification with micronutrients has a role. Specifically, the matrix should include the type of beneficiary (school feeding, children at clinics, emergency feeding, and development assistance) and the different types of delivery mechanisms (government to government, PVOs, multilateral).

Specifically, the Economist will:

1. Compile a food aid matrix detailing the parameters of the review as noted above.

2. Review existing documentation on current costs of fortifying P.L. 480 commodities and costs associated with related quality control measures in place. Using the recommendations of the team members, make recommendations that will minimize the constraints (costs, toxicity) to consumption and utilization of specific micronutrients in target populations in a cost-effective and sustainable manner.

3. Work closely with industry representatives to evaluate the costs of different options to improve fortification of P.L. 480 commodities. These include costs associated with use of alternative fortificant compounds; costs associated with optimizing fortificant levels of iron, etc.; and costs associated with fortifying additional P.L. 480 commodities (e.g., oil with vitamin A).

4. For specific target groups, e.g., refugee and displaced populations or school feeding programs, evaluate costs/benefits associated with providing micronutrients through fortified P.L. 480 food commodities versus providing vitamin/mineral supplements.

5. Evaluate costs of alternative quality control measures and monitoring options for micronutrient fortification of P.L. 480 commodities, including the potential of using more efficient and powerful methods for data gathering, analysis, and reporting than those currently used, and assessing case studies from countries and regions which can illustrate innovative and effective ways of development impact monitoring and reporting. Generally ensure the information systems are conceptually sound, thorough, cost-effective, and user-friendly.

6. Based on the review above, submit typewritten report (with diskette in WordPerfect) and participate in the final preparation of the paper by reviewing and evaluating the technical, institutional, and financial feasibility and constraints to the implementation plan and proposed programs and projects in coordination and collaboration with other team members.

## ANNEX B:
## Persons Consulted*

| | |
|---|---|
| George Beaton | Department of Nutrition, University of Toronto, Canada |
| Rita Bhatia | UNHCR, Geneva, Switzerland |
| Leland Brenneman | World Vision |
| Mary Chamblis | USDA FAS |
| James D. Cook | Medical Center, University of Kansas, Kansas City, KS |
| Frances Davidson | USAID, G/PHN/HN/CS |
| Betsy Faga | Protein Grain Products International |
| Susan Gebhardt | USDA HNIS |
| Sylvia Graves | USAID/BHR |
| Steve Hansch | Refugee Policy Group |
| Suzanne Harris | International Life Science Institute |
| Ann Hilger | Watson Foods, West Haven, CT |
| Gordon Huber | Wenger, Sabetha, KS |
| Dean Jensen | USDA ASCS |
| Sam Kahn | USAID, G/PHN/HN |
| Indulitis Kancitis | Dairy Group/USDA ASCS |
| Lynnda Kiess | USAID, G/PHN/HN |
| David Kohley | Riviana Foods, Inc., Houston, TX |
| Marianne Leach | CARE |
| Ray Leenhouts | Dow Chemicals Co., Midland, MI |
| Ventakesh Mannar | Micronutrient Initiaive, Ottawa, Canada |
| Tom Marchione | USAID/BHR |
| Don McCaskel | Riceland Food, Inc., Stuttgart, AR |
| Judy McGuire | World Bank |
| Steve Miteff | USDA ASCS |
| Eugene Morris | USDA ARS |
| Catherine Murchie | USDA ASCS |
| Jose Pineda | USDA ARS |
| Sonya Rabeneck | CIDA, Ottawa, Canada |
| Jeanne Rader | FDA CFSAN |
| Peter Ranum | Atochem, Buffalo, NY |
| Tina Sanghvi | LAC-HNS (ISTI) |
| Joe Siegal | World Vision, Detroit, MI |
| Scott Solberg | CARE, Atlanta, GA |
| Andrew Swiderski | USAID, G/PHN/HN |
| Sam Sylvetsky | Fortitech, Inc., Schenectady, NY |
| Michael Toole | CDC, Atlanta, GA |
| John Vanderveen | FDA CFSAN |
| Paul Whittaker | FDA CFSAN |
| Sam Wright | Wright Enrichment Company, Crowley, LA |
| Tom Zopf | Food Aid Management Group |
| Vince Zortman | Rice Millers' Association |

* Unless otherwise noted, located in greater Washington, DC area.

## Annex C:
## Vitamin Premix Added to P.L. 480 Title II Blended Foods (a)

| Vitamin Premix | Amount for 2,000 lbs of Final Food |
|---|---|
| Thiamine mononitrate | 2.5g |
| Riboflavin | 3.5g |
| Vitamin C (stabilized ethyl-cellulose coated) | 364.0g |
| Pyridoxine hydrochloride | 1.5g |
| Niacin | 45.0g |
| Ca, d-pantothenate | 25.0g |
| Folic acid | 1.8g |
| Vitamin B-12 | 36.0mg |
| Vitamin A palmitate (stabilized)(1) | 21.0 million IU |
| Vitamin D (stabilized) | 1.8 million IU |
| Vitamin E | 68,000 IU |
| Soy flour, defatted (toasted) or starch to reach to total weight (additional soy flour may be added as a carrier, if desired) | |
| **Total** | 2.0 lbs |

Source: USDA/ASCS Commodity Announcements, February 1, 1994
(a) Vitamin premix added to blended processed foods including corn soy blend and wheat soy blend.
(1) Vitamin A palmitate (stabilized) must be added in encapsulated form containing 250,000 IU vitamin A palmitate/g. Particle size must pass through a U.S. Standard No. 50 sieve, at least 90 percent through a U.S. Standard No. 60 sieve, and at least 45 percent through a U.S. Standard No. 100 sieve. The product must be not less than 95 percent of the all-trans isomer as determined by the USP assay procedure. The vitamin A palmitate must have storage stability such that not more than 20 percent of its original activity will be lost when stored for 21 days at 45C in a sealed container at a level of 10,000 IU to 12,000 IU per pound in cornmeal or wheat flour having a moisture content in the range of 13.5 to 14.5 percent.

## Annex D:
## Mineral Mix Added to P.L. 480 Title II Blended Foods

| Minerals | Amount for 2000 lbs of Final Food | |
|---|---|---|
| Tricalcium phosphate, food grade, must have an apparent specific gravity of 0.55g per cc or less (1) | 40.00 lbs | |
| Zinc sulphate, hydrated FCC grade ($ZnSO_4.7H_2O$) | 0.08 lbs | (36g) |
| Ferrous fumarate, purified FCC grade | 0.92 lbs | (418g) |
| Iodized salt (0.007%/Iodine) | 13.00 lbs | |
| **Total** | 54 lbs | |

Source: USDA/ASCS Commodity Announcements February 1, 1994.

## Annex E:
## Enrichment Mix Added to P.L. 480
## Processed Cereal (a)

| Enrichment Ingredients | Amount Added per Pound Cereal | |
|---|---|---|
| | Minimum | Maximum |
| Thiamine | 2.0mg | 3.0mg |
| Riboflavin | 1.2mg | 1.8mg |
| Niacin or niacinamide | 16.0mg | 24.0mg |
| Vitamin A palmitate (b) | 10,000 IU | 12,000 IU |
| Calcium (in harmless and assimilable form) | 500mg | 750mg |
| Iron (reduced iron, 325mesh, to be used as the iron source) (c) | 13.0mg | 26.0mg |

Source: USDA/ASCS Commodity Announcements, February 1, 1994.
(a) Enrichment ingredients added to cornmeal, bulgur, soy-fortified cornmeal, soy-fortified bulgur, and soy-fortified sorghum grits.
(b) Vitamin A palmitate (stabilized) must be added in encapsulated form containing 250,000 IU vitamin A palmitate/g. Particle size must pass through a U.S. Standard No. 50 sieve, at least 90 percent through a U.S. Standard No. 60 sieve, and at least 45 percent through a U.S. Standard No. 100 sieve. The product must be not less than 95 percent of the all-trans isomer as determined by the USP assay procedure. The vitamin A palmitate must have storage stability such that not more than 20 percent of its original activity will be lost when stored for 21 days at 45C in a sealed container at a level of 10,000 IU to 12,000 IU per pound in cornmeal or wheat flour having a moisture content in the range of 13.5 to 14.5 percent.
(c) Ferrous sulfate is not to be used as the iron source in any processed cereal products purchased for export assistance programs.

## Annex F:
## Nutrient Content of Corn Soy Blend (CSB)

| Nutrients | Nutrients in CSB Components | | | | Total Nutrients in CSB (100g) |
|---|---|---|---|---|---|
| | Cornmeal degerminated (a) (69.65g) | Soy flour defatted (21.85g) | Soy oil (5.5g) | Vit/Min Premix (b) | |
| Energy (Kcal) | 256.0 | 71.4 | 48.6 | -- | 376 |
| Protein (g) | 5.92 | 11.24 | -- | -- | 17.16 |
| Calcium (mg) | 3.5 | 52.7 | -- | 774 | 830 |
| Phosphorous (mg) | 38.7 | 147.3 | -- | 400 | 586 |
| Iron (mg) | 0.77 | 2.02 | -- | 15.20 | 17 99 |
| Zinc (mg) | 0.50 | 0.54 | -- | 0.90 | 1.94 |
| Vitamin A (IU) | 288 | 0.80 | -- | 2314 | 2314 |
| Vitamin D (IU) | -- | -- | -- | 198 | 198 |
| Vitamin E (mg) | 0.23 | 0.042 | -- | 7.5 | 7.8 |
| Vitamin C (mg) | -- | -- | -- | 40.1 | 40 |
| Thiamine (mg) | 0.098 | 0.153 | -- | 0.28 | 0.53 |
| Riboflavin (mg) | 0.035 | 0.055 | -- | 0.39 | 0 48 |
| Niacin (mg) | 0.700 | 0.571 | -- | 5.9 | 6.27 |
| Pantothenic acid (mg) | 0.218 | 0.436 | -- | 2.75 | 3.42 |
| Pyridoxine (mg) | 0.180 | 0.125 | -- | 0.165 | 0 470 |
| Folacin (mcg) | 33.5 | 66.7 | -- | 198 | 298 |
| Vitamin B-12 (mcg) | -- | -- | -- | 3.97 | 3.97 |
| Iodine (mcg)(c) | -- | -- | -- | 45.5 | 45.5 |

Source: Calculations based on USDA Handbook 8 and USDA/ASCS Specifications, February 1994
(a) Yellow corn only
(b) Vitamin and mineral premix, USDA/ASCS 1994 Specifications
(c) Iodine contained in iodized salt at 45.5mcg/100 grams of CSB.

## Annex G:
## Nutrient Content of Cereals and Soy Flour[a]

| Nutrients | Cornmeal [b] (degerminated) | White Rice (milled) | Wheat Flour (whole grain) | Bulgur | Sorghum | Soy Flour |
|---|---|---|---|---|---|---|
| | Amounts per 100g of commodity | | | | | |
| Energy (Kcal) | 366 | 365 | 339 | 342 | 339 | 327 |
| Protein (mg) | 8.5 | 7.1 | 13.7 | 12.3 | 11.3 | 51.5 |
| Calcium (mg) | 5 | 25 | 24 | 36 | 28 | 241 |
| Phosphorous (mg) | 84 | 115 | 348 | 300 | 287 | 674 |
| Iron (mg) | 1.1 | 0.8 | 3.88 | 2.46 | 4.4 | 9.24 |
| Zinc (mg) | 0.72 | 1.09 | 2.93 | 1.93 | NA [c] | 2.46 |
| Vitamin A (IU) | 413 | 0 | 0 | 0 | 0 | 0 |
| Vitamin D (IU) | 0 | 0 | 0 | 0 | 0 | 0 |
| Vitamin E (mg) | 0.33 | 0.13 | 1.23 | 0.16 | NA | 0.2 |
| Vitamin C (mg) | 0 | 0 | 0 | 0 | 0 | 0 |
| Thiamine (mg) | 0.14 | 0.07 | 0.447 | 0.23 | 0.237 | 0.7 |
| Riboflavin (mg) | 0.06 | 0.05 | 0.220 | 0.11 | 0.14 | 0.25 |
| Niacin (mg) | 1 | 1.6 | 6.365 | 5.11 | 2.93 | 2.61 |
| Pantothenic acid (mg) | 0.31 | 1.01 | 1.010 | 1.05 | NA | 2 |
| Pyridoxine (mg) | 0.26 | 0.16 | 0.340 | 0.34 | NA | 0.57 |
| Folacin (mcg) | 48 | 8 | 44 | 27 | NA | 305 |
| Vitamin B-12 (mcg) | 0 | 0 | 0 | 0 | 0 | 0 |

Source: USDA Handbook AH-8

[a] Natural nutrient content of cereals and soy flour without fortification or enrichment.

[b] Yellow corn only.

[c] NA - Nutrient data not available.