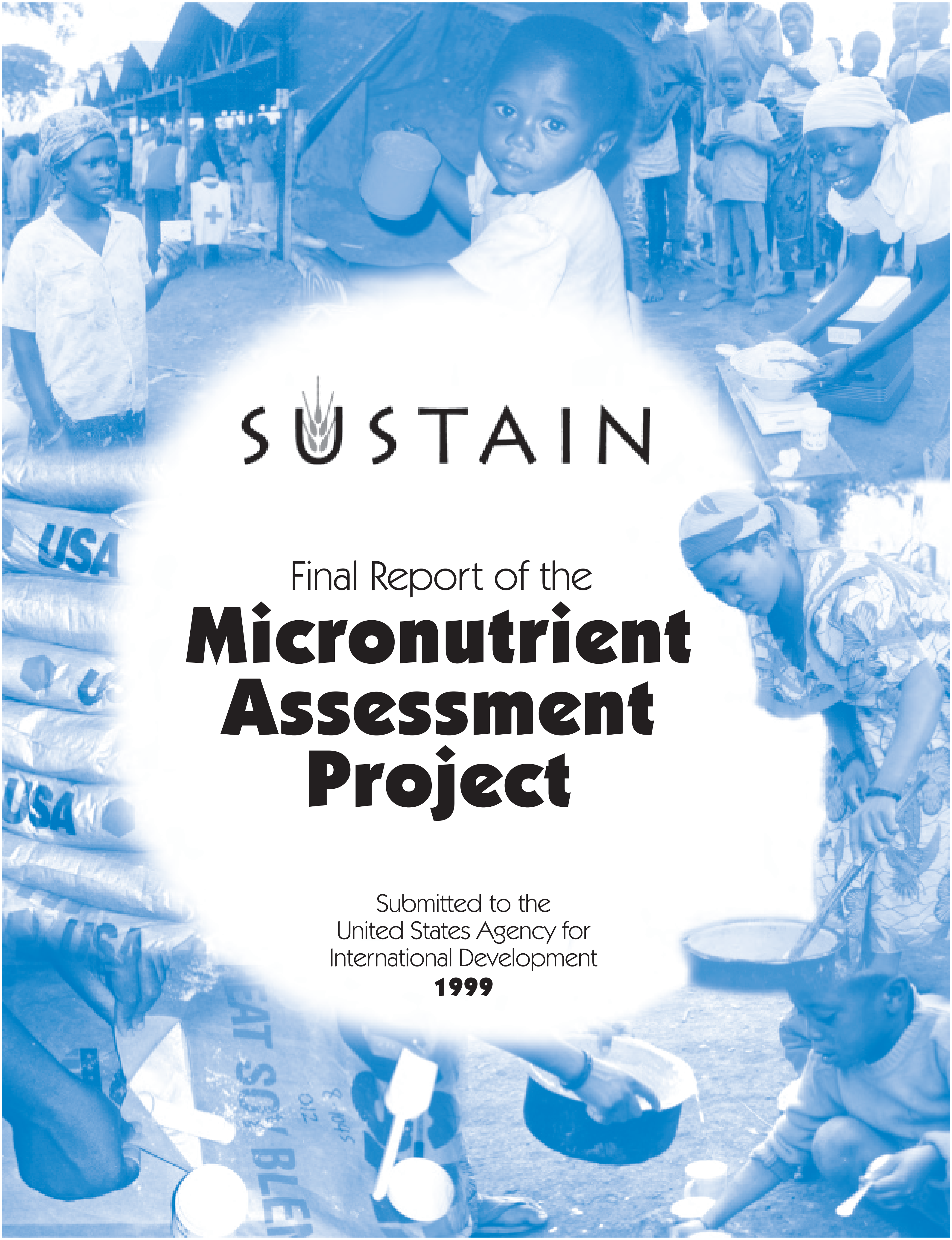

SUSTAIN

Final Report of the

Micronutrient Assessment Project

Submitted to the
United States Agency for
International Development
1999

SUSTAIN
SHARING UNITED STATES TECHNOLOGY TO AID IN THE IMPROVEMENT OF NUTRITION

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SUSTAIN'S objective is to enhance the quality, safety, and availability of food in developing countries. In collaboration with the U.S. Agency for International Development (USAID), SUSTAIN provides access to specialized expertise in food science and technology to improve the level of nutrition in developing countries. The assistance is provided by experienced professionals from the U.S. food industry, who serve on a volunteer basis.

SUSTAIN'S assistance is provided through assessments, technical assistance, and workshop training. To examine technical issues in more depth, SUSTAIN conducts scientific studies and organizes expert advisory panels, technical symposia, and technical publications. Depending on the nature of the request, SUSTAIN'S assistance is provided either through long-term or short-term initiatives.

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LIST OF ABBREVIATIONS

ADRA	Adventist Development and Relief Agency
AOAC	Association of Analytical Chemists
AACC	American Association of Cereal Chemists
AV	Analytical Variation
BHA	Butylated hydroxyanisole
BHR	Bureau for Humanitarian Response
BHT	Butylated hydroxytoluene
CARE	Cooperative for American Relief Everywhere
CDC	Centers for Disease Control
CFSA	USDA Consolidated Farm Service Agency
CIN	Committee on International Nutrition
COV	Coefficient of variation
Cp	Production capability
Cpk	Production capability index
CRS	Catholic Relief Services
CSB	Corn soy blend
FDA	Food and Drug Administration
FFP	Office of Food for Peace
FGIS	Federal Grain Inspection Service (also know as GIPSA, below)
FHI	Food for the Hungry
GIPSA	USDA Grain Inspection, Packers and Stockyards Administration
HPLC	High performance (pressure) liquid chromatograph
KCCO	Kansas City Commodity Office of the USDA, FSA
MCH	Maternal child health
MT	Metric ton = 1000 kilograms
NAS	National Academy of Sciences
NAFTA	North American Free Trade Agreement
NGO	Non-governmental organization
OCF	Other Child Feeding programs
PVO	Private voluntary organization
P.L. 480	Public Law 480
RDI	Recommended daily intake
TCP	Tricalcium phosphate
SUSTAIN	Sharing United States Technology to Aid in the Improvement of Nutrition
TCP	Tricalcium Phosphate
TQSA	Total Quality Systems Audit
UNHCR	United Nations High Commissioner for Refugees
USAID	United States Agency for International Development
USDA	United States Department of Agriculture
WFP	World Food Programme
WSB	Wheat soy blend

EXECUTIVE SUMMARY

Background

The Micronutrient Assessment Project (MAP), a three-year scientific study on three continents, was launched in1996 with funding from the United States Agency for International Development's (USAID) Bureau for Humanitarian Response, Office of Program, Planning, and Evaluation (BHR/PPE) with technical support from the Global Programs, Field Support and Research Bureau, Center for Population, Health and Nutrition, Office of Health and Nutrition (G/PHN/HN). This initiative was a result of increased attention in both Bureaus to the effective delivery of micronutrients (i.e., vitamins and minerals) to their target populations and to the shared concern that the impact be optimized. The MAP study was conducted by a team of food science and nutrition experts representing SUSTAIN (Sharing U.S. Technology to Aid in the Improvement of Nutrition), the Washington, D.C.-based nonprofit organization dedicated to improving nutrition and food quality worldwide. The goal of the MAP was to determine the level of micronutrients in the fortified food commodities provided in the United States (U.S.) P.L.480 food assistance program which reaches the mothers, children, and refugees targeted by emergency and development feeding programs in developing countries.

The USAID Office of Food for Peace administers the P.L. 480 Title II program, and through its partner organizations identifies recipient food needs. USDA procures the needed foods from U.S. producers and processors to be shipped in the form of Title II grants. In fiscal year (FY) 1998, under the Food for Peace Program, the U.S. donated more than 1.6 million metric tons of food commodities, reaching 43 million people in 53 countries worldwide. U.S. fortified food aid commodities have the potential to deliver micronutrients to the majority of these people. Over one-third of all FY 1998 Title II food aid, or 590,000 metric tons, worth $183 million, consisted of micronutrient-fortified cereals.

The MAP investigated the stability (from production to consumption) and uniformity in the manufacturing process of key micronutrients added to processed Title II food commodities. It focused on vitamin A, niacin, and the mineral iron, tracking the levels of these nutrients at both ends of the supply chain, from U.S. manufacturer to overseas consumer. Of the several vitamins added to processed foods, vitamin A was selected for intensive study because of its significant health benefits, its relatively high cost when added as a fortificant and the challenge posed by the labile nature of this vitamin. Among other things, vitamin A plays an important role in maintaining eyesight and a strong immune system. Vitamin A deficiency (VAD) is a chronic, preventable problem, affecting 40 million and blinding over one million annually. The U.S. is part of a global effort to eliminate vitamin A deficiency and significantly reduce hunger early in the 21st Century. As a result, fortifying food aid commodities with vitamin A and eliminating the deficiency has become a high priority for the U.S. Congress, USAID, and other development/health organizations and nations worldwide. Iron and niacin, both of which are relatively stable micronutrients, were also chosen for their health benefits but also because of their potential use as "indicators" in quality assurance tests for fortification processes in the future. Though not part of the MAP study, the vitamin C results reported here were investigated by the SUSTAIN study team in a parallel activity supported by a separate cooperative agreement with USAID/G/PHN/HN. Vitamin C, like vitamin A, is a labile and expensive fortificant and therefore subject to the same questions regarding cost-effectiveness and potential loss during shipping, storage, and cooking. These issues, coupled with vitamin C's significant health benefits (e.g., fighting infection, aiding in iron absorption) sparked special interest in Congress.

In 1997 and 1998, the MAP, in conjunction with the vitamin C pilot program, sampled fortified blended and processed P.L. 480 cereals at delivery sites in Bolivia, Haiti, India, Peru and Tanzania to determine the stability of vitamins A and C during shipping and storage. The MAP team sampled blended food commodities, corn soy blend (CSB) and wheat soy blend (WSB) – before and after cooking – in Haiti and Tanzania and had them tested to determine vitamin retention during normal food preparation. Two models were used for studying vitamin stability: in the first, certain fortified batches of CSB and WSB were manufactured specifically for the MAP and followed to Haiti, India, and Tanzania; in the second, bulgur and wheat flour from lots/batches fortified and sampled in the normal manufacture process were collected by the MAP team for laboratory analysis. The lots then followed their normal path to Bolivia and Peru where they were sampled and tested again for vitamin A level after shipping and storage. The team also directly sampled and tested levels and uniformity of vitamin A, niacin, and iron at eight U.S. manufacturing plants involved in P.L. 480 commodity fortification, and tested vitamin A levels in official USDA samples of bulgur and wheat flour from six other plants. A comparison of these samples to the samples taken at warehouses and delivery sites provided the basis for the vitamin A stability studies.

Results

Production Level Concerns: SUSTAIN's study team uncovered serious shortcomings in the fortification of some P.L. 480 processed and blended cereals, particularly in the levels of vitamin A. The MAP visited eight production facilities and analyzed samples from over 12 plants and 25 production runs. MAP scientists directly sampled and tested food aid samples from five of the six U.S. manufacturing plants producing CSB, one of the two producing WSB, both plants producing bulgur wheat products, and several plants producing wheat flour. At the time of testing, problems were found in the processing of large and small manufacturers alike and ranged from low levels at manufacture to variable levels in the same production lot (i.e., lack of uniformity in processing). One producer had persistently low vitamin A levels at manufacture with many products containing as little as one-quarter of USDA-specified vitamin A levels for these fortified, processed food aid commodities. Three of the eight mills directly sampled by MAP during production were below target levels for vitamin A, two significantly (57% and 60% of target) and one moderately (70% of target). Composite lot samples provided by USDA showed similar concerns in six of ten wheat flour production runs sampled. The causes of these losses may include (1) poor quality vitamin A which is destroyed upon exposure to air during the production process; (2) low levels of the vitamin being added and; (3) separation of the vitamin from the commodity during production. Of the nine production runs directly sampled in this study, four showed problems in uniformity and/or meeting the minimum standards or targets for micronutrients. Reasons for this included faulty feeders, inadequate operating procedures or poor plant design. Products from these plants would not consistently deliver sufficient specified levels of micronutrients to food aid recipients in developing nations.

Shipping and Storage: There was little loss of vitamins and minerals found in the dry commodities during shipping and storage. The conclusion from these results is that vitamin loss in the dry commodities is statistically significant, but it is not a serious overall problem. The one-third loss of vitamin A found in WSB nine months after production was the largest loss observed, but this level of loss is within the expected vitamin A loss endured by the US food industry. WSB makes up a relatively small proportion of processed food aid, and manufacturers could probably remedy the problem through a change in the fortificant used. There was little loss of vitamin A in wheat flour or bulgur or of vitamin C in CSB and WSB. There is no need to change the packaging, lower the moisture content or implement any of the related actions that have been proposed. Any such action would likely be expensive and ineffective. The one action recommended is that the mills and premix manufacturers make sure the vitamin A they use is of good quality and meets the stability standards specified by the USDA.

Consumer Level Losses: The MAP also identified losses at the consumer end**. Cooking processes used routinely with CSB and WSB by Title II recipients overseas can cause large losses of vitamins A and C.** When blended, fortified Title II cereals were used to make a simple gruel at delivery sites, using a common preparation method for feeding children, the vitamin A retention was only 50% of post-shipment levels. Better vitamin retention (70%) was found in foods with lower moisture content, such as dumplings and ugali, a paste made out of corn meal and CSB that is commonly prepared in Africa. Cooking losses were not altogether unexpected in these fortified, blended cereals, since the labile nature of these vitamins leaves them vulnerable to losses in certain cooking processes.

Overall Losses Estimate: Taking this cooking loss, combined with low initial levels supplied by some of the products and vitamin A losses during storage of WSB, **the amount of vitamins A and C actually delivered to the recipients was well below expectations.** In some extreme cases, only trace levels of these two vitamins were found in the cooked food.

Accomplishments

Throughout its course, this project demonstrated to the producers, USDA and PVOs the importance USAID attaches to micronutrient delivery in food aid commodities. A primary recommendation was the need for the USDA to better monitor and enforce micronutrient fortification of Title II, P.L. 480 food commodities, recognizing the importance now attached to delivering needed vitamins and minerals to the recipients of this program.

Furthermore, it became clear that the economic losses to the government could be significant. In one extreme example, the government was paying nearly six dollars to fortify every metric ton of bulgur wheat with vitamin A, while the product contained less than two dollars worth. The cost of quality control would have been a fraction of these losses.

As a result of the MAP findings, USDA is working with USAID to establish standards for analytical micronutrient "indicators" that will be used to determine whether the different commodities have been properly fortified, a program of regular testing of each lot of fortified commodity, and an enforcement program to ensure that the producers are meeting fortification standards.

USDA has also begun investigating the adoption of a Total Quality Systems Audit (TQSA) program that focuses on the manufacturing process and operating procedures. It is an alternative to end-item inspections and verifies that a supplier has the capability to produce food products which consistently meet USDA standards, to deliver on time, and to respond to and resolve consumer complaints.[1] TQSA evaluates capability and performance of these factors. Programs similar to TQSA have become one of the main tools used by the U.S. food industry to ensure continued quality. USDA is implementing TQSA over the next five years for all vendors who sell food products to the Farm Service Agency (FSA). SUSTAIN endorses the current efforts by USDA to establish a TQSA program for P.L. 480 commodities, and recommends that fortification practices be included as a component.

The visits of the SUSTAIN MAP team to the U.S. production sites caused producers to become more aware of the fortification component of their operation. It has already led one producer to make the effort to improve the uniformity and quality of its fortification practices, resulting in the development of a new fortification premix, modified operating procedures and improved quality control testing. Other plants have been made aware of problems in fortifying their products, but it is not known to what extent corrective action has been taken.

Some of the problems found with low vitamin A levels at production and loss of vitamin A in the dry commodity resulted from some companies ignoring existing USDA specifications on the type of vitamin A to be used in these commodities. SUSTAIN recommends that USAID work with USDA to enforce these specifications and encourage producers and vitamin suppliers to seek ways to improve vitamin A stability. Continued exploration of new forms of vitamin C that can provide improved stability during food preparation is also recommended. Attention should be turned to identifying and promoting cooking methods that maximize vitamins and recommendations should be made to PVOs and other organizations receiving fortified P.L. 480 foods on such cooking techniques.

The expert panel advising SUSTAIN on the MAP activity has concluded that the recommended minimum micronutrient standards in combination with a TQSA program is the only practical and achievable way to ensure adequate levels and uniformity of micronutrients in fortified Title II P.L. 480 food commodities. USAID and USDA are already working toward these goals through the establishment of a SUSTAIN-administered International Food Aid Commodity Secretariat. This forum provides the opportunity for private and public stakeholders to conduct dialogue regarding food aid micronutrient quality assurance and delivery.

While this report identifies some serious problems in delivering vitamin A through fortified, cereal-based foods, it recommends that vitamin A fortification of these foods continue owing to the recognized importance of delivering vitamin A to food aid recipients. As an additional means of supplying vitamin A to the target population, the MAP team prepared a report on the feasibility of adding vitamin A to vegetable oil for use in Title II programs. The report recommended, and USAID and USDA initiated, the fortification of refined vegetable oil as of December 1, 1998.

Recommendations

The results of this study have led to the following specific recommendations for USAID, USDA and their partners to improve the implementation of the food aid program:

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[1] See: USDA, Farm Service Agency, Commodity Operations website http://www.fas.usda.gov/daco/trends/TQSA.htm). Vendors will have to develop and implement quality management systems (QMS), based on International Organization of Standards (ISO 9000) quality standards, which states how they will produce and deliver their food products. A trained USDA audit team will review QMS and its implementation to ensure consistently safe, high quality products. Vendors will be rated and qualified to bid only if they meet the standards.

- Monitor and enforce minimum micronutrient specifications currently applicable to processed fortified P.L. 480 cereals at U.S. food aid processing plants.
- Establish, monitor and enforce a minimum, end-product vitamin standard for one vitamin and one mineral in fortified blended foods (CSB and WSB) at U.S. food aid processing plants.
- Establish vitamin A as the micronutrient indicator for all P.L. 480 processed fortified cereals. In processed fortified and blended foods (such as CSB and WSB), establish vitamin A as the vitamin indicator and iron as the mineral indicator.
- Remove all maximum standards on micronutrients or enforce minimum standards only in P.L. 480 processed cereals.
- Bulgur and wheat flour producers, especially, need to work with fortification premix producers to correct the problem with low vitamin A levels found in their commodities.
- Incorporate micronutrient fortification in the Total Quality Systems Audit (TQSA) at U.S. food aid processing plants.
- Consider allowing combined addition of vitamins and minerals to CSB and WSB.
- USAID and USDA should help facilitate technical assistance to manufacturers of fortified P.L. 480 commodity producers on how to improve compliance and uniformity of micronutrient addition.
- Enforce the current stability specifications on the vitamin A required in fortified P.L. 480 commodities.
- Encourage mills and premix suppliers to improve vitamin A stability.
- Continue fortifying processed and blended foods with vitamin A.
- Investigate use of the more heat stable forms of vitamin C in CSB and WSB.
- Investigate precooked foods as an alternative means to deliver vitamin A and C to food aid recipients.
- Include information on vitamin retention in the Commodity Reference Guide for use by field partners who provide food aid.

I. INTRODUCTION AND BACKGROUND

The U.S. provides much of its global food assistance under the Agricultural Trade Development and Assistance Act of 1954, also known as Public Law 480 (P.L. 480). Since its enactment, the United States Government has distributed some 375 million metric tons of food valued at over 50 billion dollars, working through many partners in the U.S. and abroad, including non-governmental and private voluntary organizations (NGOs and PVOs), agricultural producer groups, and the World Food Program (WFP). The U.S. Government (USG) continues to be the largest food assistance donor worldwide. Through P.L. 480 food assistance program (Titles I, II and III), the United States has provided 1.1 billion dollars worth of food assistance in fiscal year 1998, using 2.84 million metric tons of commodities, including value-added fortified processed and blended Title II foods which are the focus of this study. Under the Title II program, the U.S. Agency for International Development (USAID) through its field partners and country Missions, identifies food aid needs and the Office of Food for Peace in Washington authorizes the U.S. Department of Agriculture (USDA) to competitively procure food commodities from U.S. private food processors.

In the 45 years since its inception, USDA and USAID have improved the quality and safety of the food commodities shipped to needy people under P.L. 480 and other food aid legislation. Specifically, micronutrient fortification of P.L. 480 food commodities, which began in 1966, has enhanced the potential to address nutritional deficiencies in developing countries and emergency relief situations by providing additional vitamins and minerals through a wide variety of processed foods. In fiscal year 1997, this amounted to six micronutrient fortified cereals and two specially blended and fortified cereals, totaling 590 metric tons (MT) that reached over 20 million people (see Table 1). The value in fortifying these products has grown in importance in recent years with the discovery of the critical role micronutrients play in the human diet, not only in preventing deficiencies under conditions of scarcity and poverty, but also in enhancing health and well-being more generally.

Table 1. P.L. 480 Title II Fortified Cereal Foods

Commodity	Quantity Provided During FY 1997 (1,000 Metric Tons)	Average Cost[2] ($/MT)	Value (Million $)
Fortified Processed Cereals:			
Wheat Flour	161	305	49.1
Bulgur	68	258	17.5
Bulgur, Soy Fortified	60	276	16.6
Corn Meal, Soy Fortified	43	310	13.3
Corn Meal	24	311	7.5
Sorghum Grits, Soy Fortified	14	304	4.3
Fortified Blended Cereals:			
Corn Soy Blend (CSB)	211	335	70.7
Wheat Soy Blend (WSB)	9	458	4.1
Totals	**590**		**183.1**

Changes in the fortification standards for the fortified P.L.480 commodities have occurred simultaneously with increased knowledge in the nutrition and food processing sciences. These changes include the following:

- 1982 increase in iron and B vitamin levels in fortified wheat flour;
- 1988 doubling of vitamin A levels in all fortified cereal based foods;
- 1997 inclusion of folic acid in fortified processed cereals;
- 1998 magnesium added and zinc levels increased in CSB and WSB, while the level of B_{12} decreased;
- 1998 vitamin A added to refined P.L. 480 vegetable oil.

The most recent changes were based, in part, on recommendations from a USAID-commissioned 1994 technical review paper (1) and field studies by SUSTAIN (8). Some of the recommendations have not been implemented,

[2] Average delivered cost including freight.

such as switching to more absorbable forms of iron, while others led to changes not being made, such as the increase in vitamin C levels (see Appendix A).

In 1996 Congress directed USAID to initiate a pilot program to increase the vitamin C content of CSB and WSB to 90 mg/100 g and report on the results. A pilot study conducted by SUSTAIN provided the basis for the recommendation by the National Academy of Sciences accepted by USAID to retain the level of 40 mg/100 g of vitamin C in these blended foods.

In the course of investigating these proposed changes, USAID developed an overall concern with the uniformity and stability of vitamins and minerals added to all fortified and blended P.L. 480 food commodities. Laboratory studies done for USAID with the assistance of the U.S. Army food research laboratory at Natick, Massachusetts and by the FDA in 1992 suggested possible problems with the stability of added vitamin C, but they were not able to quantify how much would be lost under field conditions. A 1994 field test in India (2) showed high variability in vitamin A levels in CSB, with some products containing far less than the target levels. This suggested problems with fortification at the plants and/or significant losses during shipping and storage. The OMNI project study in 1994 (1) recommended establishing a quality control program for ensuring micronutrient content of P.L. 480 foods prior to shipment. Based on SUSTAIN's vitamin C pilot study, in 1997 the National Academy of Sciences recommended that better assurances of product quality should be given before changing nutrient profiles of food aid (10). (Detailed discussion of these studies are presented in Appendix A.)

One aspect of this concern has been the specification and enforcement of standards for micronutrient enrichment and fortification by USDA. All processed food provided under Title II programs, with the exception of rice, is required to meet the U.S. standards for enriched cereals, meaning that they must be fortified with B vitamins (thiamin, riboflavin, folic acid and niacin) and iron. USDA policy requires that any changes made in the U.S. enrichment standards for foods with a U.S. Standard of Identity automatically be applied to the same foods used in the Title II Food for Peace program. Originally, enrichment was intended to replace nutrients lost in refining. The levels of micronutrients added by manufacturers now make up for the difference between the minimum enrichment standard and the amount of the nutrient remaining in the refined cereal, plus a reasonable overage to ensure that the standard will be met. In addition to meeting the appropriate U.S. domestic enrichment standard, all Title II processed foods are required to be fortified with vitamin A because of the great need for this vitamin by most populations targeted for food aid.

Table 2. Micronutrient Standards[3] for Fortified P.L. 480 Processed Cereals

Commodity	Thiamin mg/100g	Ribo- flavin mg/100g	Folic Acid mg/100g	Niacin mg/100g	Vitamin A IU/100g	Iron mg/100g	Calcium mg/100g
Wheat Flour and Soy Fortified Flour	0.64	0.40	0.15	5.29	2205-2644	4.41	110
Corn Meal, Soy Fortified Corn Meal, and Corn Masa Flour	0.44 - 0.66	0.26 - 0.40	0.15 - 0.22	3.53 - 5.29	2205-2644	2.86 - 5.73	110 - 138
Bulgur and Soy Fortified Bulgur	0.44 - 0.66	0.26 - 0.40	0.15 - 0.22	3.53 - 5.29	2205-2644	2.86 - 5.73	110 - 138

Therefore, micronutrient standards for fortified processed foods, shown in Table 2, are the same as those used under U.S. Food and Drug regulations for these foods, with the additional requirement of vitamin A and calcium. They are given as a minimum with overages left to good manufacturing practices for wheat flour or as a minimum-maximum

[3] Single values indicate a minimum with overages left to good manufacturing practices. Two values separated by a dash (-) indicate a minimum - maximum allowable range.

range with the others, the same as required under FDA standards for enriched cereal foods. Vitamin A, however, is always given as a range. There is no FDA standard for enriched bulgur wheat, so the standards for bulgur were based on those existing for wheat flour at the time bulgur was developed as a P.L. 480 commodity many years ago. The standards for wheat flour were subsequently increased to the higher values, but bulgur remained at the old levels. These micronutrient standards for fortified processed foods are operative for all processors. However, because the commodities are not tested for micronutrients, there has been no real monitoring or enforcement of these specifications or standards.

The micronutrient fortification for the two blended foods (CSB and WSB) is shown in Table 3. USDA regulations specify the composition of the vitamin and mineral premixes to fortify CSB and WSB, which are the same for both commodities. In contrast to the processed fortified cereals, the values shown in Table 3 for the blended foods are *target levels* added and not necessarily the *final levels* in the product, although many groups have used them, incorrectly, in that manner. USDA applies no final product (end-product) specifications for blended commodities and there is currently no testing of the commodities for final micronutrient content to ensure that they have been properly fortified.

Table 3. Micronutrient Addition Target Levels in Fortified Blended Foods

Micronutrient	units per 100g	CSB/WSB Target Levels, prior to January 1998	CSB/WSB Target Levels, after January 1998
Calcium	mg	775	775
Calcium d Pantothenate	mg	2.76	2.76
Folic acid	mg	0.20	0.20
Iodine	ug	45	57
Iron	mg	14.7	14.7
Magnesium	mg	0	82.5
Niacin	mg	4.96	4.96
Pyridoxine HCl	mg	0.17	0.17
Riboflavin	mg	0.39	0.39
Salt	g	0.65	0.81
Thiamin	mg	0.28	0.28
Vitamin A	IU	2,315	2,315
Vitamin B_{12}	ug	3.97	1.32
Vitamin C	mg	40.1	40.1
Vitamin D	IU	198	198
Vitamin E	IU	7.5	7.5
Zinc	mg	0.91	3.98

To assist USAID in resolving these concerns, on September 30, 1995, USAID's Bureau for Humanitarian Response (BHR) set up Cooperative Agreement No. FAO-0800-A-00-5033-000 with the National Cooperative Business Association (NCBA) for SUSTAIN to establish the Micronutrient Assessment Project (MAP) to research the stability and availability of micronutrients in Title II food aid commodities (Appendix B). SUSTAIN had been identified by the Global Bureau as an organization with access to the wide technical expertise available through its network of U.S. food technologists and other food and nutrition experts, which could assist USAID with assessing, enhancing and establishing quality assurance procedures in the fortification and enrichment of P.L. 480 commodities.

To help follow up on these recommendations and to coordinate a variety of technical resources dealing with micronutrients in P.L. 480 commodities, the USAID Office of Food for Peace requested that SUSTAIN establish the International Food Aid Commodity Secretariat (IFACS). This mechanism was established in May 1997 to facilitate the exchange of information among all P.L. 480 stakeholders.

This ***Final Report on the Micronutrient Assessment Project*** provides a full accounting of the background, methods, accomplishments, analysis and recommendations derived from the MAP activities over the course of its Cooperative Agreement. The remainder of this report is divided into the following sections:

- A description of the **MAP Goal and Objectives**: Section II
- **Procedures and Methods** used throughout the MAP data collection and analysis: Section III
- **Findings and Conclusions** regarding micronutrient levels, uniformity and stability: Section IV
- **Recommendations & Implications**: Section V
- A review of MAP and other related SUSTAIN **Accomplishments**: Section VI
- **Appendices** which provide relevant subject reviews, a list of advisors, scope of work, and details of the data analysis.

II. THE MICRONUTRIENT ASSESSMENT PROJECT (MAP)

A. Program Goal and Objectives

The overall goal of the MAP was to contribute to the alleviation of nutritional deficiencies in the developing world. The specific purpose was to contribute to USAID/BHR's knowledge of the stability and availability[4] of micronutrient fortificants in food aid commodities and to make recommendations designed to improve the long-term effectiveness of that program on the target populations.

To accomplish the purpose, activities were designed with the following project objectives (as stated in Cooperative Agreement No. FAO-0800-A-00-5033-00, 28 September 1995):

1. To contribute to an increased understanding of the stability and loss of the micronutrients added to food aid commodities.

2. To assess the stability of selected micronutrients added to specific Title II commodities, from the point at which the micronutrients are initially added to the commodities up to the point of consumption in the field.

3. To identify specific conditions that result in the loss or deterioration of micronutrient fortificants.

4. To identify particular problem areas in the handling and storage of fortified food aid commodities that are detrimental to the stability of added micronutrients.

5. To make recommendations for improving the stability and nutritional availability of specific fortificants.

6. To identify particular problem areas in the processing of fortified food aid commodities that affect the availability of micronutrients in the finished commodity at plant sites, and to make recommendations on improvement of this processing.

The MAP Cooperative Agreement originally contained the first five research questions related to the stability of specific micronutrients (i.e., what amount is retained) in food aid commodities up to the time they reach the consumer. A sixth objective was added on the basis of preliminary tests because it was clear that the amount of nutrient reaching the consumer is not only a matter of stability, but also a matter of the commodity leaving the manufacturing plant with the correct level of fortificant present throughout the entire shipment[5]. A primary task of MAP was to make recommendations on food aid commodities at the end but also throughout the course of the study.

B. Study Design

The study was designed to provide answers to the following questions related to fortified Title II, P.L. 480 food commodities:

1. What are the levels of added micronutrients found in specific food aid commodities at the point of production in the U.S and how close do they come to meeting current standards or targets? This is the amount of the added vitamin or mineral actually found in the processed food at the plant.

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[4] "Availability" in this context means the amount of micronutrients provided by the food and not the bioavailability, or how much of the added micronutrients are absorbed by the body.

[5] Tests run in connection with the Vitamin C Pilot activity indicated serious problems with the levels and uniformity of that added micronutrient at the manufacturing plant. Some of the companies and specific plants were also involved in the fortification of food aid commodities with other vitamins and minerals. With the approval of the USAID/BHR and the Farm Service Administration (FSA) of the USDA, the MAP team arranged for subsequent tests from samples taken at production sites. These tests revealed low levels of vitamin A in bulgur and wheat flour and led to the additional testing of vitamin A in official Government (FGIS) samples taken of those two commodities.

2. What is the uniformity of the selected micronutrients found in specific food aid commodities at the production plants and previous to shipping? This is the amount of variation in the vitamin or mineral within bags, between bags and between lots.

3. What is the stability (degree of retention) of these micronutrients following shipping and storage of the food? This degree of retention is the proportion of the vitamins retained in the dry commodity from the point it leaves the production plant and the point just prior to cooking (or other food preparation) by consumers.

4. What is the stability of vitamins during normal food preparation methods? This degree of retention is the in the proportion of the vitamins retained in the food commodity from the point just prior to food preparation by a consumer to the point when the cooked commodity is about to be consumed.

Fortified Food Commodities Selected for Study

This study investigated the most frequently used food aid commodities. The annual use of the different fortified P.L. 480 commodities, provided in Table 1 for FY97, shows that CSB has the highest volume (211 MT) followed closely by wheat flour (161 MT). Next are soy fortified and regular bulgur (128 MT) and then corn meal (67 MT). The MAP selected these four most widely used fortified cereal-based foods and WSB. WSB, along with CSB, is used primarily as a complementary food and therefore is a potential source of micronutrients to the highly vulnerable weaning-age child group. Because of the importance of CSB, both in terms of volume and as a means of supplying micronutrients, CSB became the principal subject of the study.

While wheat flour, corn meal and bulgur products are fortified with certain micronutrients, CSB and WSB are the only two foods in the food aid commodity mix that are "blended", meaning in this case that they are fortified with protein, fat and a full spectrum of vitamins and minerals. Only CSB and WSB have added vitamin C. WSB was studied in detail in the Vitamin C Pilot Study because it had vitamin C added, and so it was included in the MAP, even though it is produced in small amounts (9 MT) compared to the other commodities. It was also instructive to include WSB because it is alone is fortified using a batch process, as opposed to the continuous process used with all the other food aid commodities.

Micronutrients Investigated

Out of the many micronutrients added to food aid, the MAP selected vitamins A and C because of their high cost, nutritional importance and poor stability relative to the other micronutrients. Iron and niacin levels were selected because their high level of stability provides an additional basis for judging uniformity of the applied vitamin and mineral premixes. (See Appendix I, Tables 3-5 for the nutritional profile and added nutrients to Title II food aid.).

Standard analytical procedures run by an established commercial lab were used throughout the study in order to assure consistency in the analytical methodology. Using only one laboratory minimized potential inter-laboratory variations. Following standard protocols provided measurements that could be compared to those of other studies using the same procedures.

Rationale for Production Sites Selection

Plants and production contracts for processed and blended food aid were chosen to illuminate the range of processing done. These intensive site studies were supplemented with samples provided by USDA from other plants and production runs. Because of the wide variability found at the first production site sampled, it was determined all eight plants producing blended foods (CSB and WSB) were selected for study, along with one production plant each for wheat flour, bulgur and corn meal. Along with the USDA samples, it was thought a good representation of the production of fortified food aid products could be obtained.

Rationale for Country and Consumer Site Selection

The MAP protocol called for product sampling in four different countries, including at least one refugee (emergency) feeding situation and one development situation. Consumer sites were selected to represent Title II development and relief activities under a variety of conditions, including wide differences in climates, length of time it took commodities to reach the recipients, cooperating sponsor groups, and types of food aid programs. Sampling trips were made to five countries on three continents. India was chosen since it is the largest Title II program worldwide, receiving 214,900 metric tons worth over $93.7 million for distribution to almost 7.5 million people in development activities in 1997. Peru, Bolivia and Haiti together represent the bulk of Title II assistance in Latin America and the Caribbean (LAC). These programs distributed a total of 168,510 metric tons valued at $87 million to 2.1 million people. Tanzania was representative of the refugee situation in Africa.

III. PROCEDURES AND METHODS

The procedures and methods required to cover the full range of micronutrient concerns were a complex combination of sampling and analytic testing that began in the U.S. processing plant and ended with cooked food in a recipient's kitchen or refugee site. In all, 150 lots of the five food aid commodities were selected for investigation and numerous analytical tests were done on the four focal micronutrients at various points along the production to consumption chain (Table 4). In addition to the testing for levels, uniformity, and stability of micronutrients, special studies were done to test the composition of the premixes, their stability in over a period in cold storage, and the food preparation under simulated conditions. MAP employed standard state-of-the-art methods for laboratory assays of nutrients and for statistical analysis.

Table 4. Summary of Sub-Studies Performed on Fortified Foods (MAP and FGIS sampling)

Nutrient	**Levels (processing plants)**		**Uniformity (processing plants)**		**Stability, dry (country sites)**		**Stability, cooked (lab. & country sites)**	
	Food*	Number	Food	Number	Food	Number	Food	Number
Vitamin A	CSB	5	CSB	4	CSB	2	CSB	3
	Cornmeal	1	Cornmeal	1				
	WSB	1	WSB	1	WSB	1	WSB	3
	WF	9	WF	1	WF	2		
	BW	3	BW	1	BW	2		
Vitamin C	CSB	5	CSB	5	CSB	1	CSB	3
	WSB	1	WSB	1	WSB	1	WSB	3
Iron	CSB	3	CSB	3	CSB	1		
	Cornmeal	1	Cornmeal	1	WSB	1		
	WF	1	WF	1				
	BW	1	BW	1				
Niacin	CSB	3	CSB	3			CSB	1
	WSB	1	WSB	1			WSB	1

* WF is wheat flour and BW is bulgur wheat.

A. Determination of Levels and Uniformity at the Production Plant

Studies of Production

Production studies involved testing two types of commodity samples to determine how well the plants are fortifying P.L. 480 commodities. The first were direct samples taken during production runs by MAP scientists at plant sites over a two to three day period, representing only a few lots, except in the case of wheat flour where the samples were taken over a three week period (Table 5). The other type of samples was composite lot samples taken by FGIS at the plants and sent to an analytical laboratory identified by MAP.

Table 5. Summary of Production Plants Directly Sampled

Plant[6]	Product	Date sampled	Type of production
A	CSB	June '96	Continuous
B	WSB	July '96	Batch
C	CSB and Corn Meal	Oct. '96	Continuous
D	CSB	Jan. '97	Continuous
E	CSB	Apr. '97	Continuous
F	Wheat Flour	July '97	Continuous
G	Soy Fortified Bulgur	Aug. '97	Continuous
H	CSB	Aug. '97	Continuous

Method of Direct Product Sampling

Direct samples taken during a production run showed how micronutrient levels varied from hour to hour and from bag to bag. They represented conditions during a short slice in time in the production history of a particular plant. Due to concerns about the uniformity of the micronutrients added to CSB, it was decided to directly sample as many CSB plants as possible in this way. As it turned out, five of the six plants producing CSB were sampled. One plant producing each of the following products was sampled: WSB, wheat flour, corn meal and bulgur. These four represented basic differences in P.L. 480 commodities in terms of composition and particle size. In all approximately 36 production lots, averaging 125 MT each, were sampled.

Based on the recommendations of the MAP Statistical Advisory subgroup (see Appendix H) the study design called for collection of 48 samples distributed evenly over a 2 to 3 day production run. This was generally, but not always, achieved. In some cases, fewer than 48 samples were collected; in other cases, sampling took place over a longer period than three days. Ten of the samples were duplicated for use as blind analytical checks. All samples taken at the mill were sent to the laboratory within three days of sampling. Plants were instructed not to alter or slow down the production of the commodities in any way that would make them different from a normal production run. Arrangements were made through USDA and Protein Grain Product International to sample the production runs according to the following procedures:

1. The company to be sampled and the responsible FGIS field office were contacted to confirm arrangements on sampling procedures, times, and materials.
2. A SUSTAIN representative visited the production site to review the sampling procedure with plant and FGIS employees.
3. With assistance from FGIS inspectors and plant quality control (QC) staff, SUSTAIN collected samples by one of two procedures: (1) removing a filled bag from the line, scooping a sample from the top of the bag, and putting the sample into an eight ounce black plastic container with a tight snap-on lid; (2) scooping the sample from the top of the bag directly into the eight ounce plastic container just after the bag was filled. Each container was labeled with the date and time which constituted the sample number. Bag numbers and packing machine lines were also recorded when appropriate.
4. Duplicate samples were taken by removing bags from the line, mixing the top portion of the product with a scoop, and filling two sample cups. The duplicates were given different sample numbers and dummy times so that they could not be identified as such by the analytical laboratory.
5. In the case of one production run of CSB (plant A) and WSB (plant B), the sampled bags were labeled with the sample information, given a distinctive colored mark on the sides and bottom, and returned to the production line.

[6] Throughout this report production plants are identified only by a letter in order to maintain the confidentiality of the companies involved. Each letter indicates a production facility for a particular commodity. In some cases two of the sampled commodities were manufactured at the same location. Plant C produced both corn meal and CSB on the same equipment. All of the plants are located in the Midwest United States. A detailed description, with diagrams of the plants and their production processes, are provided in Appendix E.

6. Samples of the vitamin premix were taken each day from the premix feeder.
7. With help from plant personnel, SUSTAIN diagrammed the production method used and recorded the following information:
    - Times of personnel shift changes
    - Manufacturer and lot numbers of vitamin and mineral mixes used
    - Hourly production rates (bags/hour)
    - Daily temperature and weather conditions
    - Any special circumstances or events (e.g., chokes, accidents)

The samples from the production runs were sent by overnight package delivery to Lancaster Laboratories in Lancaster, Pennsylvania, for immediate testing of vitamin C (ascorbic acid) followed by testing of vitamin A, iron and any additional tests.

Vitamin Premix Samples**:** Samples of the vitamin premix used each day during production were taken directly from the vitamin feeder. They were tested for vitamin C, vitamin A and niacin by the quality control laboratories at two premix manufacturers (Watson Foods and American Ingredients) that routinely do this type of assay using high-pressure liquid chromatography (HPLC). The samples were identified only with a number, so the laboratory did not know whose products they were testing.

Within-Bag Variability**:** Within-bag variation at the production site was determined by collecting samples from soy-fortified bulgur samples at plant G. A single sample of approximately 100g was extracted from three different positions of the bag: the top third of the bag (position "a"), the middle third (position "b"), and the bottom third (position "c"). Each sample was analyzed separately.

Within-bag variation after shipping and storage was determined by collecting samples from 13 bags of CSB in Tanzania and 9 bags of WSB in Haiti. Single samples of approximately 100g each were extracted from the three different bag positions (described above) and each sample was analyzed separately. In addition, 21 bags of bulgur from one lot were sampled from one of the three bag locations.

Special Bulgur Tests**:** The MAP study had an immediate effect on improving the uniformity and long-term quality assurance at a bulgur production facility where the personnel were very concerned about the low level of vitamin A in samples tested at their plant. Because of this company's dedication to producing a quality product, they made special efforts to improve the process so that the vitamin A levels would be within specifications. These included the following measures:

1. Conducting vitamin A analytical tests on all lots of bulgur and soy-fortified bulgur produced in the plant until the problem was solved. Some of these results were made available and are shown in Appendix D;
2. Increasing the addition rate of the premix to ensure adequate levels of vitamin A fortification. This was a temporary measure because it also increased the levels of the other micronutrients being added and was more costly to the producer and hence less cost-effective for the P.L. 480 program;
3. Eliminating the suction from the packing line in case the vitamin A, which is fairly light, was being pulled out of the product. This resulted in a more dusty packing area and packing line personnel having to wear dust masks;
4. Asking the premix supplier to come up with a better premix. This resulted in a special bulgur fortification premix utilizing a special, non-dusting carrier.

Composite FGIS Lot Samples

In addition to direct sampling, MAP was provided composite lot samples by the FGIS for study. These samples are routinely taken throughout the production of a lot. The samples are then combined to represent the entire lot. These samples are used by FGIS to routinely test for moisture, protein and other properties of food aid commodities. FGIS composite lot samples are the official samples used by the USDA to determine whether a lot meets specifications for these and other properties of the food. In this way, it was possible to analytically test over 200 additional lots of food aid.

The micronutrient assay on these samples is comparable to the mean result for each lot from the direct method. These assays give a good indication of how closely the plant met the specification or target for that lot, but provided no information on the variability within that lot. The assays tell us the variability between lots, which is not provided in the first type of sample testing, and gives a much better picture of how well a plant is doing in meeting current or proposed fortification standards since they represent a much larger quantity of product produced over a longer time interval. Even these samples are limited since they are only of wheat flour and bulgur taken over two periods of a couple months each. Regular testing of these composite samples is one option to better control fortification practices.

The FGIS laboratory takes one to two weeks to complete the analyses of the lot samples received from production plants. The FGIS lab was instructed to collect all samples of wheat flour and bulgur from January 1998 through September 1998 and send them to Lancaster Laboratories for analysis. The FGIS lab collected about a month's worth of samples and held them in frozen storage before sending them out. In some cases the FGIS lab used most or the entire sample for their own analyses, so none was left for additional testing. Also, there were a number of samples received between March and June that were inadvertently discarded. On receipt of the sample, the Lancaster lab personnel recorded the information, conducted an analysis of vitamin A content and kept any remaining samples at -20° C. The time between production and vitamin A testing was between one to two months.

B. Determination of Stability of Vitamins During Shipping and Storage

Method for Determining Stability

The stability of the added vitamins was assessed by the following methods:

1. Comparison of Mean Levels

This method compares the mean and the variation of the vitamin content in the products at production to the mean and the variation of the micronutrient content in the same lot of product just prior to being used in food preparation in the recipient country. The Student's T test and confidence interval were used to determine whether the means were statistically different from each other.

2. Comparison of Paired Samples in Specially Marked Bags

Once the specially marked, sampled bags were located in the field and sampled, the vitamin content was compared to the vitamin content found in those same bags during production. The Student's T test for paired samples and confidence intervals were employed to determine whether the paired values were statistically different. This method could only be used on the WSB production since insufficient marked CSB bags were located in the field.

3. Comparison of Lot Means at Recipient Sites to FGIS Composite Samples for that Lot

This method compares the value of the vitamin content in the official FGIS composite samples taken at production to the mean of the vitamin content in the same lot of product taken at the recipient site. The Student's T test and confidence intervals were used to determine whether the levels were statistically different from each other.

Recipient Country Sites Sampled

Sampling trips were made to Haiti, Tanzania, India and Peru. A local SUSTAIN representative sampled product in Bolivia. The trips were arranged to collect samples from specific contract numbers, i.e. those which identified the production runs of interest to the MAP study. Once the MAP team had obtained confirmation from the cooperating sponsor in the recipient country that bags with the contract number of interest had arrived at the final distribution sites and were available for sampling, sampling trips were scheduled. No attempt was made to alter or expedite the normal distribution of the commodity.

Sampling Procedures

In each of the five countries dry commodity samples were collected by laying the bag flat on the ground and cutting the bag at the top, or middle, or bottom with a razor blade. A single sample of about 100g was extracted from the bag, and in most cases the position of the cut in the bag was noted. The sample was put into sampling cups with either screw-top lids or snap-seal lids. In Peru and Bolivia, however, the samples were placed in polyethylene twirl-packs, folded shut, tightly secured, and placed in a black plastic bag to protect the samples from vitamin A degrading light. SUSTAIN brought the samples back to the United States for analysis within two weeks of collection. In the case of Bolivia, the samples were sent back by overnight courier service. The sampling containers remained stored at ambient temperatures in sealed plastic bags and placed in opaque cardboard boxes until delivered to the laboratory.

Table 6. Recipient Sampling Sites

Country Site	Type/ Program	Product	Producer	Production Date	Recipient Site Sample Date	Time Interval Between Sampling (in months)
Tanzania	Refugee	CSB	Plant A	Jun 96	Jan 97	7
Haiti	Development	WSB	Plant B	Jul 96	Mar 97	9
India	Development	CSB	Plant C	Oct 96	Mar 97	5
Peru	Various	Wheat Flour	Various	Jul 98	Sep 98	2
Bolivia	Monitization	Wheat Flour	Various	Feb 98	Oct 98	9
Peru	Various	Bulgur	Plants G,L	Jul 98	Sep 98	2
Bolivia	Various	Bulgur	Plant L	Feb 98	Oct 98	9

Haiti: WSB produced by Plant B in early July was unloaded in the ADRA warehouse in Port au Prince, Haiti in mid-October 1996 and transported to the food distribution centers. For each batch, 68 bags were sampled at production and specially labeled. To allow SUSTAIN to track down the specially marked bags, ADRA was asked to deliver five of the specially labeled bags to ten pre-selected feeding centers during their normal three-month distribution cycle.

The selection of the feeding centers was based on the type of food distribution program and their location (urban versus rural). There were three types of feeding programs run by ADRA, but WSB was distributed through only two of them: the Maternal Child Health (MCH) and Other Child Feeding (OCF) programs. The locations selected were: 1) a primary MCH and a primary OCF in an urban area, and 2) two primary MCH centers and one primary OCF center in a rural area. In addition to these five locations, secondary centers in close proximity to the primary centers were selected to ensure there was a matching pair of centers in each of the five distribution areas.

Distribution to the selected centers began in late January 1996, and the sampling took place in the centers in March 1997. Typically, a center receives three months' worth of commodities at a time and the commodities are distributed to the recipients twice a month. The commodities are consumed during the two to three weeks between distributions.

Tanzania: CSB produced in Plant A between June 24 to 28, 1996, was sent to the refugee camps in western Tanzania and was distributed in December 1996. Logistics and internal transport of food commodities were handled by the World Food Programme and distribution was under the management of UNHCR. The focus in Tanzania was on observing food preparation practices and sampling CSB just prior to and after cooking. No attempt was made to determine vitamin retention in the dry CSB of this lot because of the wide variation in vitamin levels found at production.

India: CSB production was sampled at Plant C in early October 1996 and met the criteria of being in control. Four lots (136 MT/lot) of this procurement were distributed in the Cochin region in Southern India. Most of the bags sampled came from two lots only. Sampling was done at six different schools and at two different warehouses serving the area. The warehouses were privately run under contract to WFP. The bags found in the schools were kept in school pantries. The schools, which each teach from 12 to 40 children, received CSB several times a month. The CSB was provided to the schools for their school lunch program and it was served once a day.

Peru: Peru was chosen as the site to collect wheat flour and bulgur samples because of the large quantities of these two commodities sent there. The sampling trip to Peru was made September 1998. During that trip SUSTAIN first made contact with the PVOs receiving P.L. 480 commodities (PRISMA, CARE, ADRA and CARITAS) in order to explain the purpose of the MAP study and of trip sampling objectives.

Suitable contracts were located in three Peru warehouses. The bags of commodities were stacked in large piles, often 20 feet high, making it practical to sample only the top bags no more than three bags deep. In Peru very few of the bags had readable lot numbers. Either lot numbers were not printed on the bag or they had rubbed off during handing. First bags with the proper contract number and the same lot number were found and brought down to the floor of the warehouse. These were collected randomly around the warehouse when available, but in some cases the bags with the same lot number were all on the same pile or pallet. When no lot number could be found for a target contract, bags of that contract number were collected randomly from around the warehouse.

Bolivia: Bolivia was selected as the second South American country since it receives large amounts of wheat flour for monetization as part of its P.L. 480 Title II program while little wheat flour from the specific FGIS-sampled lots was found in Peru. Three contracts of interest were identified there. Two wheat flour contracts were particularly important as they had been shipped several months earlier and offered an opportunity to check the stability of vitamin A over time. They were therefore likely to show losses of vitamin A. These stocks were only still available because there had been some delay in the monetization of wheat flour in Bolivia[7]. Sampling took place during October 1998 following the same protocol as was used in Peru. Contracts of interest were located in FHI warehouses in El Alto and Potosí where the bags were stacked in piles. In contrast to Peru, many of the bags had legible lot numbers although some had faded during handling. Seventy-two samples were collected with 37 samples of wheat flour from Contract No. VEPD 01635, 18 samples of wheat flour from Contract No. VEPD 01624, and 17 samples of bulgur from Contract No. VEPD 01619. Twelve bulgur samples from Contract No. VEPD 01619 were collected in the Potosí warehouse (Almacen 35011) where some stock was still available.

C. Determination of Stability of Vitamins During Frozen Storage

In the course of this study samples of P.L. 480 commodities collected by SUSTAIN and foods prepared from them were kept in frozen storage at minus 20° C. It was not known to what degree vitamin A and vitamin C would degrade under those conditions. Ten samples of CSB and WSB that had been tested immediately after production were retested after frozen storage for the same time period used to determine stability under field conditions.

[7] SUSTAIN retained Andreina Soria de Claros, a local Consultant to collect the samples in Bolivia. She was well known to USAID and the cooperating sponsor groups in Bolivia and had assisted with the Peru sampling.

The stability of the vitamins during frozen storage should serve as a baseline of the maximum possible retention. If, for example, a vitamin retention of 80% was found under frozen storage, a vitamin retention of 80% under field storage conditions would not be a serious concern because a higher retention would be unlikely under the best of field storage conditions.

D. Determination of Stability of Vitamins During Food Preparation

Preliminary Laboratory Testing

Prior to undertaking field testing, preliminary laboratory studies were conducted at Lancaster Laboratories to gain familiarization with the basic food preparation methods used for CSB and WSB. This testing also helped establish what vitamin retention levels to expect during field work.

In these tests, four different dilutions of CSB and WSB were prepared under conditions described in Appendix D. These foods represented beverages (8% CSB), gruel samples (14% CSB or WSB), pastes (20% CSB or WSB) and dumplings (41% WSB). The preparations were cooked in a heavy aluminum pot on an electric range. The cooking times, holding times, temperatures, and pH were recorded. Samples were removed from the cooking pot at the indicated times and put into a 2 oz screw cap plastic container. The containers were then put immediately on a bed of dry ice to freeze. Samples were kept frozen until tested for vitamin content within two weeks.

Field Testing

The objectives of the field tests were to (1) document the typical food preparation methods used by food aid beneficiaries for CSB and WSB in both developing country and refugee situations and (2) to determine the vitamin C and vitamin A retention during those food preparation methods. CSB sampling took place in refugee camps in Tanzania; WSB sampling occurred in impoverished areas in Haiti. Taking into account the estimated variability of the WSB vitamin content, a member of the statistical subgroup calculated that a minimum of ten samples needed to be collected from the food prepared in Haiti.

With the assistance of the agencies distributing the food aid commodities (ADRA in Haiti and WFP in the refugee camps in Tanzania), SUSTAIN made appointments to meet with beneficiaries who use WSB or CSB regularly, at their homes. Community leaders (MCH centers in Haiti, "street" social workers in the refugee camps) asked several mothers if they would volunteer for the study. The only requirement was that they would be available for cooking at the time of the appointment with the appropriate ingredients. Our preliminary study had shown that in Haiti, the most commonly prepared WSB dishes were gruel and a vegetable broth with dumplings. In the Tanzania refugee camps the most commonly prepared CSB dishes were a gruel and *ugali*, a Swahili word referring to a stiff porridge. Upon being selected for the study, the mothers were free to choose the type of dish that they wanted to cook.

Methods of Sampling

During the sampling appointments, we met with the mothers and gave them each an extra ration of the commodity taken from the special procurement bags, which were sampled just prior to cooking. The extra rations were identical in quantity to their regular rations (one-to-two weeks worth ration). Typically, the ration is consumed within two or three weeks of distribution. This is true for the beneficiaries in Haiti and in Tanzania.

During food preparation the ingredients and weights, cooking procedures, cooking times and temperatures, and pH measurements were recorded. The length of time that the WSB or CSB commodities were placed in a water solution prior to cooking was also recorded. The type and nature of utensils used and the type of fuel used to cook the food was recorded. Critical parts of the preparation were also photographed to record the procedure.

In both Haiti and Tanzania, mothers usually serve the food immediately after cooking. Therefore, as soon as the food was ready, a representative sample of the cooked food was placed in a four ounce plastic container. This was tightly screwed closed and placed in a cooler with frozen ice packs. The containers were put into a freezer within eight hours of collection. Freezer temperatures were measured to ensure that the samples were kept frozen at all times. The frozen samples were brought back to the U.S. in a cooler with ice packs and put in a freezer until collected by Lancaster Laboratories for analysis. A recording thermometer was placed in with the samples to verify that the samples were kept below 32º F at all times.

E. Analytical Testing Methods

The dry WSB and CSB samples taken before and after cooking were analyzed for vitamin C, vitamin A, niacin and moisture content. The frozen CSB food samples from Tanzania were tested for vitamins C and A within two weeks of sampling. The frozen WSB food samples from Haiti were tested for these vitamins within three weeks of sampling. The analytical methods used are described in Appendix C and summarized in Table 7.

Table 7. Summary of Analytical Methods Used

Nutrient	Method	Range allowed for standard	% error
Vitamin A	Liquid Chromatography	1719-2173 IU/100g	9 %
Vitamin C	Fluorescent	108 – 121 mg/100g	11 %
Niacin	Colorimetric	22 - 27 mg/100g	20 %
Iron	Atomic Absorption	59 - 67 mg/100g	6 %

A NIST (National Institute of Standards and Technology) dry infant cereal reference was conducted with each set of daily tests. If the standard fell outside of the range shown in Table 7, the results were not used and the set was repeated. The allowable analytical error, as a percentage, is also shown in Table 7. The analytical error was also determined from the ten blind duplicate samples taken at the mills.

F. Statistical Analysis Methods

A statistical software program was used to analyze data collected on production samples. This program calculates a number of descriptive statistics useful in analyzing production data including *production capability indexes* (Cp and Cpk) which are shown in the results. Histograms and control charts are provided in Appendix E.

The retention of vitamins A and C was determined by first establishing whether the data fit a normal distribution. If so, a Student T-test was used to determine if there was a significant difference between the two sets of samples. If the data was not normal, steps were taken to transform it to usable form. The data was then subjected to an analysis of variance test to determine the confidence intervals. The confidence level on each mean level was calculated in order to determine the significance of any difference between the two means.

With the FGIS samples, the retention of vitamin A in each lot was determined by the Student T-test on the difference between the level in the FGIS sample and the level in the recipient samples. When multiple lots had been collected and tested, the mean level of vitamin A in the whole plant production of a contract was compared to the mean level in the recipient samples. This served to make the analysis more robust.

IV. FINDINGS & CONCLUSIONS

The procedures and methods discussed in the previous section proved to be highly appropriate range of concerns regarding the uniformity and stability of micronutrients in Title II commodities. The findings and conclusions shed light on the following questions:

(1) What are the levels of the added micronutrients in the specific fortified food aid commodities at the point of production in the United States and how close do they come to meeting current standards or targets?
(2) What is the uniformity of selected micronutrients in the commodities at production?
(3) What is the stability (degree of retention) of vitamin A and vitamin C during shipping and storage?
(4) What is the stability of vitamin A and vitamin C during food preparation?

Overall findings for all four nutrients and five commodities investigated revealed serious problems in meeting target levels and product uniformity at U.S. production facilities, and high vitamin losses were observed in the preparation of foods by program recipients, as summarized in Table 8. Relatively minor problems were found in losses in shipping and storage.

Table 8. Summary of Problems of Selected Micronutrient Stability and Uniformity in Specific Food Aid Commodities

	Corn Meal			Corn Soy Blend				Wheat Soy Blend				Wheat Flour			Bulgur	
Nutrient:	A	B3	Fe	A	C	B3	Fe	A	C	B3	Fe	A	B3	Fe	A	Fe
Problem																
(1) Levels	3	—	3	1	2	3	3	3	3	3	—	1	—	—	1	3
(2) Uniformity	3	—	3	1	1	3	1	3	3	3	—	1	—	—	1	2
(3) Shipping & Storage Stability	—	—	—	2	3	3	3	1	3	3	—	3	—	3	3	3
(4) Food Preparation Stability	—	—	—	1	1	3	3	1	1	3	3	—	—	—	—	—

Key: 1 – Serious problem detected; 2 – Minor problem exists or may exist; 3 – No problem detected; A – vitamin A; C – vitamin C; B3 – niacin; Fe – iron; "— " - Data was not collected or inconclusive

A. Micronutrient Levels During Production

Overview

The actual levels of micronutrients in the fortified P.L. 480 food commodities at the point of production is of primary importance if nutrients are to reach the food aid recipients. The two different types of samples from production plants provided different but complementary and mutually reinforcing types of results. The first were individual samples taken over a two to three day period during a production run and reveal how well expected levels are met and how well levels are maintained from bag to bag. They represent conditions during a short slice in time in the production history of a particular plant. There is no way of definitely knowing whether any uniformity and compliance problems observed during this period were temporary or long term, except through the equipment and design of plants. The second test was an analysis of FGIS composite lot samples. This analysis provided a good indication of how closely the plant met the minimum specification or target for that lot, but it did not indicate the variability within that lot. The results show the variability between lots, (which is not provided in the first type of sample testing), and give a much better picture of how well a plant meets current or proposed fortification standards as they represent a much larger quantity of product produced over a longer time interval. Regular testing of these composite samples is one option to better control fortification practices.

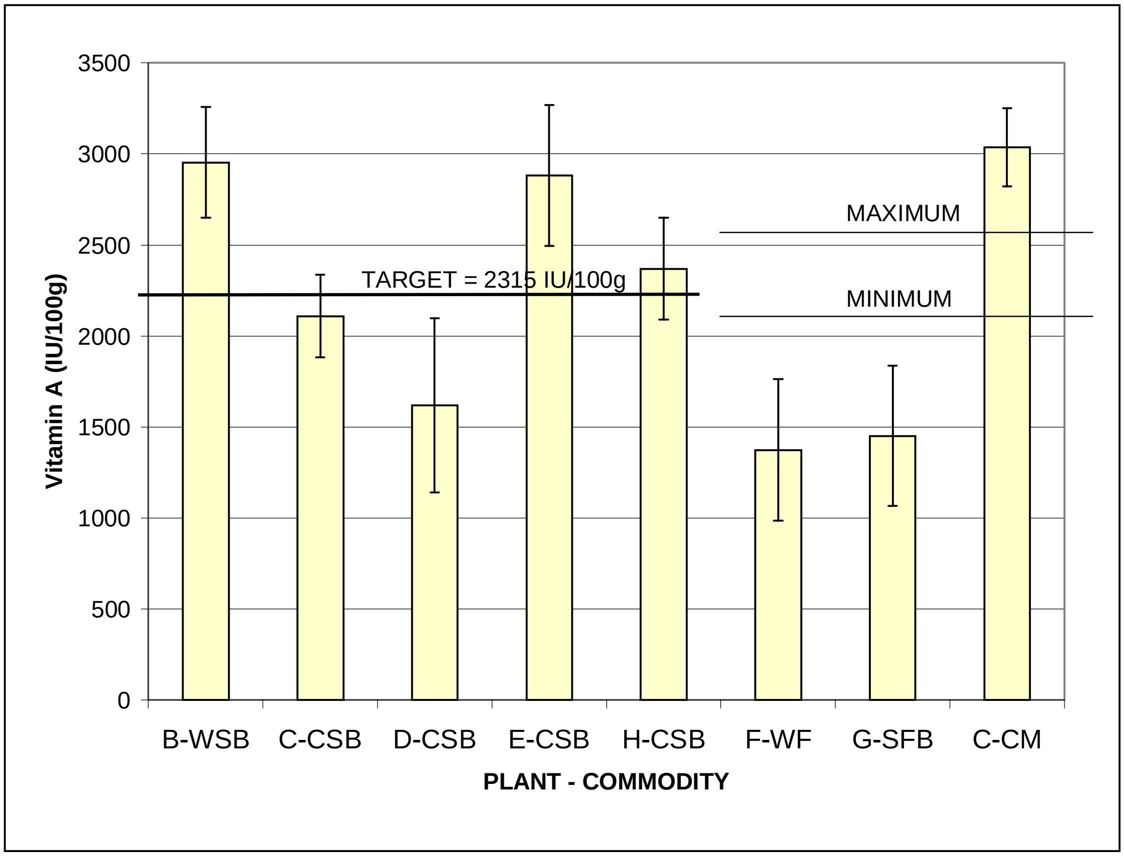
Results

Some plants have serious problems meeting the target levels of vitamin A in CSB and the minimum standard for vitamin A in wheat flour and bulgur. One CSB plant also had problems in meeting target levels for vitamin C. None of the sampled plants had problems meeting minimum levels of niacin or iron.

Samples Collected at Plants
Vitamin A was tested in the production runs at eight different plants. Three of those showed mean levels well below the minimum standard or target, as illustrated in Figure 1. CSB plant D had a mean vitamin A level at 70% of target. Plant F showed a mean vitamin A level in wheat flour at 57% of the minimum standard. Plant G had mean vitamin A levels at 60% of the minimum. Corn meal plant C showed a mean vitamin A level above the maximum.

One of the six production runs in which vitamin C was tested had a mean vitamin C value well below the target, i.e. CSB from plant D was 69% of the target. Plant A also had vitamin C levels below the target but it was within one standard deviation due to the large variability at that plant. None of the four plants tested for niacin (Figure 3) or the six plants tested for iron (Figure 4) showed low levels of those two micronutrients.

Figure 1. Summary of Vitamin A Results from Production Plants[8]



[8] Each bar in Figures 1 through 4 shows the mean micronutrient level of roughly 48 samples of a particular commodity from a particular plant. The vertical line on each bar shows ± standard deviation for that set of data centered around the mean. A target level line is shown for the blended foods (CSB and WSB). Minimum-maximum lines, or a single minimum line, are shown for the fortified processed foods. Full results are given in Appendix E.

Figure 2. Summary of Vitamin C Results from Production Plants

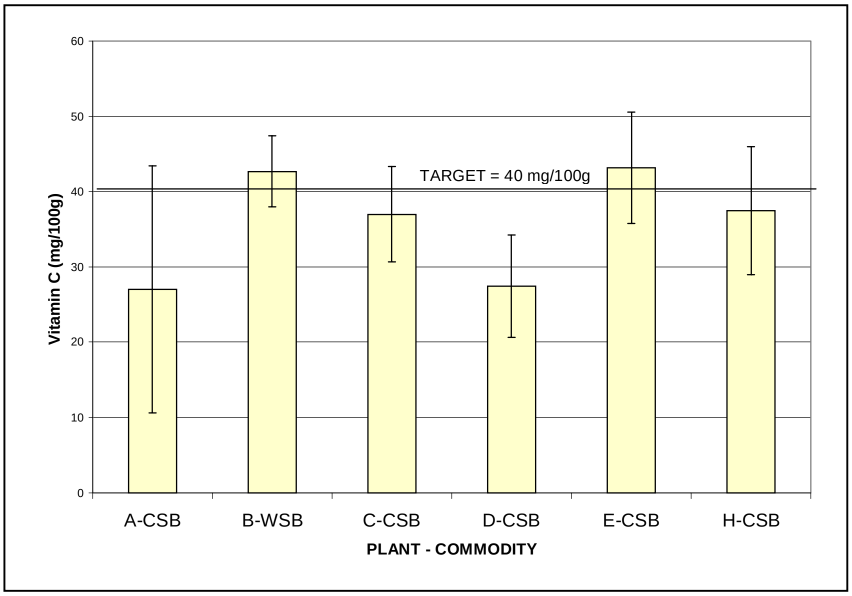


Figure 3. Summary of Niacin Results from Production Plants

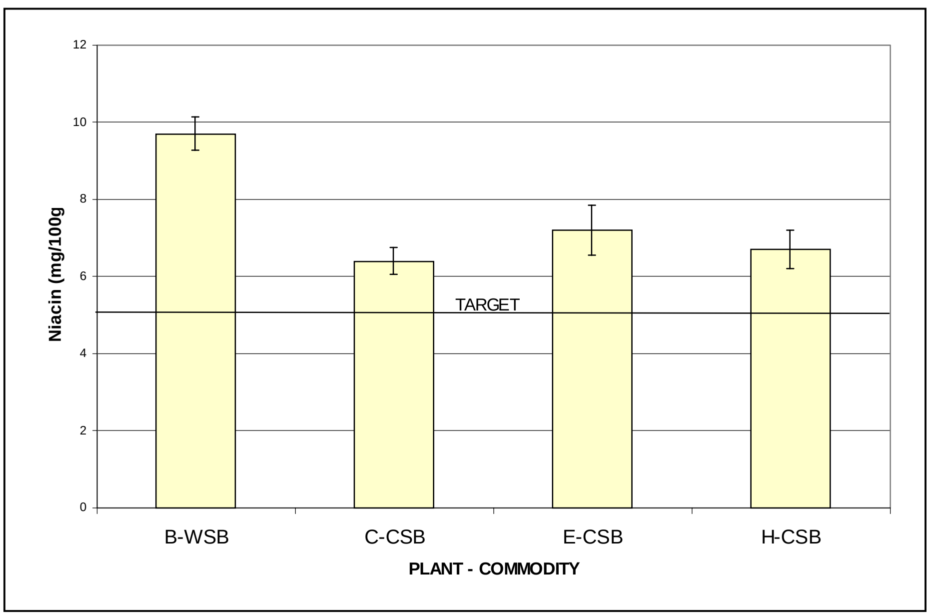
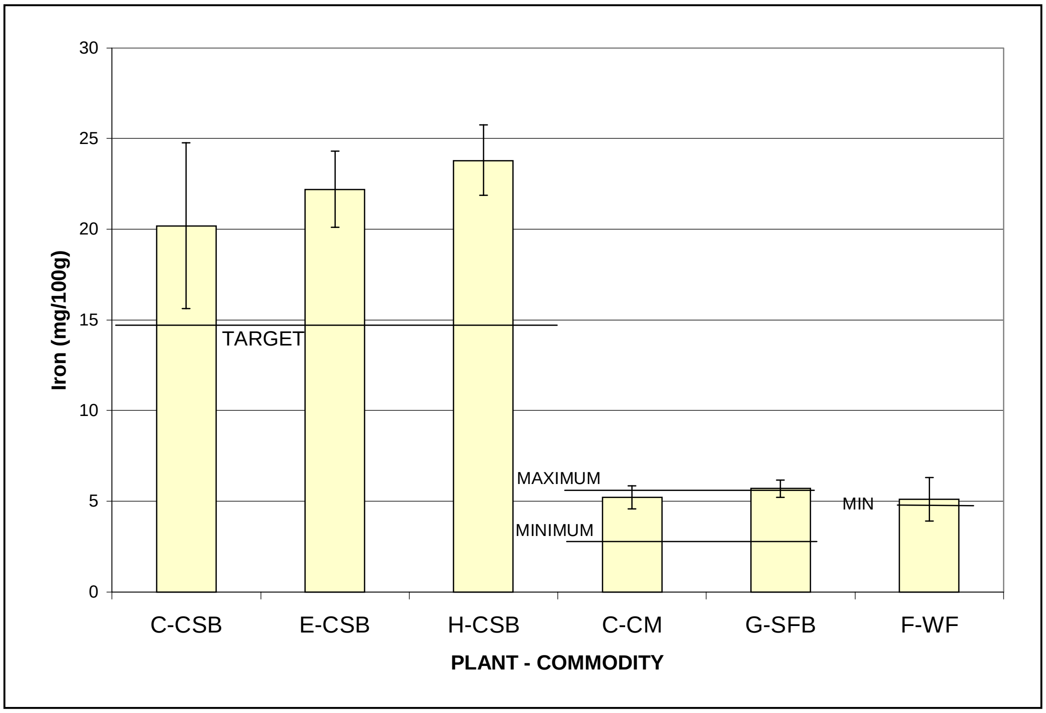


Figure 4. Summary of Iron Results from Production Plants



FGIS Samples

The results on the FGIS composite lot samples, summarized in Tables 9 and 10 with full results in Appendix D, show **a serious problem in plants meeting the current minimum vitamin A specification in wheat flour and bulgur**. This problem is of greatest concern in the bulgur samples from Plant L, where the vitamin A levels were less than a quarter of the minimum specification.

Table 9. Summary of Vitamin A Assays on FGIS Composite Lot Samples of Wheat Flour

Plant	No. of Samples	Mean (IU/100g)	Standard Deviation (IU/100g)	COV (%)	Minimum (IU/100g)	Maximum (IU/100g)	Mean as % of Min. Spec.
I	6	1982	190	9.6	1720	2220	90%
J	6	1223	112	9.2	1090	1350	56%
F	6	1205	186	15.4	920	1420	55%
I	18	2157	180	8.3	1860	2420	98%
K	43	1674	287	17.1	810	2170	76%
M	49	1660	166	10.0	1090	1980	75%
-	7	1447	129	8.9	1250	1640	66%
-	3	1380	130	9.4	1200	1500	63%
-	15	1505	136	9.0	1250	1770	68%
-	1	1450	N/A	N/A	N/A	N/A	66%
-	1	1830	N/A	N/A	N/A	N/A	83%
Total	155	1669					76%

The wheat flours were produced by a number of different flour mills. While uniformity between the flour lots was generally good, vitamin A levels in wheat flour were below the minimum specification. This could be due to some loss during processing and prior to testing, but it could also be due to improper adjustment of the vitamin premix feeders.

Table 10. Summary of Vitamin A Assays on FGIS Composite Lot Samples of Bulgur

Plant	Number of Samples	Mean (IU/100g)	Standard Deviation (IU/100g)	COV (%)	Minimum (IU/100g)	Maximum (IU/100g)	Mean as % of Min. Spec.
L	3	542	167	30.8	370	840	25%
L	14	525	72	13.7	349	650	24%
L	7	374	55	14.7	320	470	17%
G	20	2348	566	24.1	1630	3520	107%
G	6	1190	116	9.8	1010	1380	54%
L	6	598	87	14.6	470	760	27%

There are only two plants that produce bulgur and soy fortified bulgur. The vitamin A results on FGIS samples from four contracts of bulgur produced by Plant L showed levels far less than what it is supposed to contain. There was also high variability between the lot samples. The FGIS results indicate that Plant G was also having a problem in achieving specified levels of vitamin A in bulgur.

Plant G Bulgur Studies

Plant G management was not pleased with the results of the initial soy fortified bulgur samples collected at their plant. As a result, they took a number of steps to improve the situation. The first action was to turn off the air suction at packout, in case the vitamin A was being sucked out of the bulgur. This resulted in a dusty packout area. The other action was to increase the addition rate of the vitamin/iron premix by about 50% to make up for the missing vitamin A. This was a temporary measure since it was costly to the plant and resulted in higher than necessary levels of iron and the other vitamins being added. The mill asked their vitamin/iron premix supplier to provide a stickier, less dusty premix for fortifying bulgur. The vitamin A results obtained from the initial run of this new premix are given in Appendix G and summarized by sets 2 and 3 in Table 11. A SUSTAIN representative was present during this test run.

Five runs were made of fortified bulgur with two different kinds of vitamin premixes added at different addition rates. The first two sets were made with conventional powdered vitamin/iron premix. The next three sets were made with a sticky/granulated vitamin/iron premix using wheat germ as the carrier. During each production run, samples were taken from the top of the bin going into the packer, from the bag just after filling, and from the sealed bag at the top, middle and bottom sections.

When the conventional premix was added at 50% over label directions, the mean vitamin A content in the bag was about what would be expected from the addition, and was above the target. With the new premix, an addition of 10% over label claim yielded a product that met the target. The level of vitamin A in the bottom of the bags was 19% higher than that in the top portion of the bag, but this difference was not statistically significant.

Table 11. Summary of Vitamin A Levels in Bulgur at Plant G

SET	Type of Samples	Feeder Setting	Mean Vitamin A (IU/100g)	Number of samples	Percent of Minimum	COV
1	Bag		1451	39	66 %	27 %
2	Bag	150%	3177	3	144 %	
3	Bag	110%	2620	3	119 %	
4	FGIS Composite		2348	20	107 %	11 %

Plant G continued to use this new premix, at 5% over label directions. This worked quite well as shown by set 4 results in Table 11. They monitored the vitamin A levels by doing their own testing using the standard AACC Colorimetric procedure. Their results agreed quite well with those from Lancaster Labs. For example, their mean level on set 3 in Table 11 was 2783 IU/100g and 2367 IU/100g on set 4. Unfortunately, the latest set of FGIS samples from plant G that were tested, (See Table II), indicate a drop in the vitamin A levels below target, showing the need for continued vigilance.

Conclusions

The failure to meet minimum standards of vitamin A is a serious problem. Low initial vitamin levels have potentially damaging consequences in that it results in the delivery of continued low levels of needed micronutrients. The USDA can solve this problem by having the FGIS monitor micronutrient levels by testing the regular composite lot samples, as is being planned. Ensuring that each lot is properly fortified, (as determined by a micronutrient "indicator" such as vitamin A), and meets some minimal standard, would help guard against recipients suffering from micronutrient deficiencies, providing they are receiving adequate rations and vitamin losses are not excessive.

The fortified blended foods (CSB and WSB) currently have micronutrient "*process standards,*" which function as *targets*. This allows the micronutrient content to vary in either direction around the target. A minimum standard is needed in order to enforce compliance. The minimum level proposed for vitamin A in CSB and WSB is 80% of the target, or 1850 IU/100g. Of the five productions of blended foods, CSB from plant D would have failed to meet this proposed minimum for vitamin A.

The fortified processed foods currently have minimum micronutrient standards that are not being met for vitamin A. This study uncovered several examples of products failing to meet existing fortification standards. For example, both FGIS samples and samples collected in the field showed that the vitamin A content in bulgur produced by plant L was low enough to demand immediate correction. In addition, wheat flour produced by a number of different plants also showed low vitamin A levels.

The reason for low vitamin A in fortified processed foods is not clear. There are a number of possible causes including low levels of vitamin A in the premix, loss of vitamin A activity in the premix during storage, not enough premix being added at the mill, loss and oxidation of vitamin A in the flour during pneumatic transfer, or any combination of these factors.

The results of the analysis of wheat flour in Bolivia showed virtually no loss of vitamin A after nine months of storage so **it is unlikely that vitamin loss after milling and packaging is the cause of this problem**. However, it may be that some of the vitamin A is rapidly oxidized and lost during the milling process when it is exposed to air during feeding and pneumatic conveying. The more the vitamin is exposed to air, the greater the loss. This could also be a function of the quality of the coating and antioxidation system in the vitamin A palmitate (250SD type) product being used. A product of poor quality may offer little protection against air oxidation during milling.

The vitamin A content of the vitamin premix samples collected were all close to specifications, as shown by the results in Appendix D. There was no evidence that the low vitamin levels seen in some of the commodities was a result of a faulty vitamin premix containing low initial levels of vitamin A. More work needs to be done to determine why some of the processed foods contain low initial levels of vitamin A so that the problem can be corrected.

The low vitamin A levels at production seem to be more of a problem with wheat flour and bulgur than with CSB and WSB. Only one production of CSB (Plant D) was really low in vitamin A, and that appeared to be caused by faulty premix addition rates since the vitamin C was also low. Their problem may be primarily due to an incorrect feeder adjustment. The nutrient feeders at Plant D were old and worn and may not have been able to hold their calibration or deliver a consistent rate of product. The equipment for metering nutrients at Plants C, E and H were newer, well maintained, and correctly calibrated. Plant H showed good uniformity with all the micronutrients except for vitamin C.

The vitamin A in corn meal from Plant C was above the maximum of the minimum-maximum range. This brings into question the utility of having so narrow a range, or having a maximum at all, since it is hardly larger than the normal process variation or even the analytical error, as shown by the allowable error in the NIST standard.

B. Micronutrient Uniformity at Production

Overview

Some reasonable uniformity[9] in the distribution of added micronutrients within fortified P.L. 480 food commodities is needed if the diets of food aid recipients are to contain a fairly constant level of these nutrients. There were three types of micronutrient uniformity investigated in this study: (1) within bag uniformity, (2) between bag uniformity, and (3) the uniformity between lots. The within bag uniformity was determined by sampling bags at production and recipient sites at three locations within the bag: top, middle and bottom. Between bag uniformity was determined by sampling roughly 48 different bags over a two to three day production run. Between lot uniformity was determined by testing the composite FGIS lot samples.

Full results for each plant can be found in Appendix D. The analytical results of samples collected at the plants, as well as the distribution histograms and control charts for the micronutrients for each consecutive sample, are shown in Appendix E and help to visualize how the nutrient value varied over the production run. Figures 1 through 4 also show one standard deviation above and below the mean.

Results

Within bag uniformity was good. Student T- tests showed no significant difference (P>0.05) in micronutrient levels from top to bottom of the bags of samples taken at production. The only suggestion of possible difference or segregation was in the plant bulgur samples where the samples from the top of the bag were slightly lower in vitamin A content from the middle or bottom of the bag.

Within bag variation after shipping and handling was determined by sampling from bags of CSB in Tanzania and WSB in Haiti at three different bag locations (top, middle and bottom). There was variation between samples taken from the three bag locations but the variability was consistent throughout the bag, indicating that there was no systematic stratification or concentration of the vitamin within one part of the bag.

Samples were also taken from different bag locations for bulgur and wheat flour in Peru and Bolivia. There did appear to be lower levels of vitamin A in the top portion of bulgur bags, where the FGIS sample would have been taken, but these differences were not statistically significant, so no firm conclusion can be made. For example, in one bulgur contract in Peru the eight samples from the top portion of the bag averaged 1225 IU/100g while the middle and bottom averaged 1609 and 1777 IU/100g respectively. In Bolivia the samples taken from the middle and bottom of the bags were 14% higher in vitamin A content, but the difference was not statistically significant. The vitamin A content of the wheat flour samples showed no difference by bag sample location.

The CSB plants had generally poor uniformity for vitamins A and C. Only one CSB plant (C) had poor uniformity for iron (COV = 23%) and all the plants tested for niacin showed good uniformity for that vitamin. CSB

[9] The variability of a set of samples can be used as an inverse measure of the degree of uniformity. The standard deviation is a measure of variability. This can also be expressed as the coefficient of variation (COV) which is the standard deviation as a percentage of the mean.

Plant A had the worst uniformity with a COV of 61% for vitamin C. CSB plant D had high vitamin A variability (COV = 30%). CSB Plant C, which had good uniformity for vitamin C and niacin, was poor for iron (COV = 23%), which is added separately from the vitamins.

The WSB plant had good uniformity for all the micronutrients tested, which is not unexpected since it is a batch operation as opposed to the continuous fortification used in all the CSB plants.

The wheat flour and bulgur plants had poor uniformity for vitamin A. The COV for vitamin A at bulgur plant G was 27% and 26% at wheat flour plant F, which also had poor uniformity for iron (COV = 23%).

The vitamin C and A between bag variation found in the delivered CSB and WSB was no worse than that found at production and often slightly better. The variability of vitamin A in the bulgur samples collected was much greater than that in wheat flour. The COV for wheat flour in Peru was less than 8%, which is quite good, and 8 to 12% for those collected in Bolivia. Bulgur samples had a COV over 25%.

The uniformity of vitamin A *between lots* was generally good in wheat flour but not in bulgur. Seven of the nine different wheat flour sets tested had COVs of 10% or under (Table 9). Of the six sets of bulgur tested, all but one had COVs over 10% (Table 10).

Conclusions

The within bag uniformity is generally a function of segregation during packing or separation during handling and storage. Fine powder products, like wheat flour and CSB, are less likely to be subject to those problems than the coarser products like bulgur, particularly when packed in large bags of 50 to 100 lbs as these are. **This study showed there is no serious problem with segregation or separation of the micronutrients after packout.**

The results on this study showed there is room for improvement in the uniformity of added micronutrients. It is difficult to say what level of micronutrient variability in fortified foods is needed or acceptable. Clearly, the wide variation seen in CSB Plant A, where vitamin C levels ranged from near zero to several times the target value, is unacceptable by any standard. At the other end of the scale, WSB Plant B and corn meal Plant C showed excellent uniformity, but the same degree of uniformity may not be possible in other plants using processes and equipment more prone to causing variability.

The problem of poor uniformity from bag to bag will be difficult to monitor since the FGIS does not routinely collect or test individual samples to determine uniformity, as was done in this study. Perhaps the best way to make improvements in this area is by proper application of a Total Quality Systems Audit (TQSA). Under that program plants will have to demonstrate they have the proper equipment, design and procedures necessary to produce a uniform product.

Plants may be more motivated to improve their fortification systems and equipment if they are required to meet minimum micronutrient levels for one or more indicators as is recommended by this report. This will result in improved uniformity since producing companies will take pains to decrease low levels for fear of being fined or having a product lot rejected, while avoiding excessively high levels for economic reasons. This will give a competitive advantage to those plants able to maintain the best uniformity.

While poor uniformity of micronutrients in fortified P.L. 480 food commodities is a concern, it is not as serious a problem as the low levels of micronutrients found in some of the products. Correcting the first problem of compliance will lead to an improvement in uniformity as well. Therefore, efforts should be directed at making sure the levels of micronutrients contained in these products at the point of shipment are adequate since that is the easiest to achieve and the most important from a nutritional health standpoint.

C. Stability of Micronutrients After Shipping and Storage of Commodities

Overview

The micronutrients added to fortified P.L. 480 food commodities would provide limited benefit to food aid recipients if most of those nutrients are lost from the food during normal shipping and storage of the dry commodities. One of the primary objectives of this study was to determine if the large loss of vitamins A and C during shipping and storage suggested by Atwood et al (3) and others was, in fact, a problem that needed to be solved. This was done by comparing the vitamin A and vitamin C levels in commodities prior to shipping to those in the same commodities at the recipient site.

Vitamin Stability in the Blended Foods

No serious problem with the stability of vitamin C was found in the dry commodities (CSB and WSB) during shipping and storage. There was some loss of vitamin A.

The full analytical results on the CSB samples collected in India and WSB samples from Haiti are given in Appendix D. The following Tables 12 and 13 summarize the results. This stability component of the study does not include data from Tanzania because the CSB pilot production run sent to Tanzania did not contain sufficiently uniform distribution of vitamins to allow for an efficient test of stability.

There were two different batches of WSB tested in this study. One had the conventional level of vitamin C added and the other had an experimental high level added. The two batches were made in the same plant one just after the other, but a different vitamin premix was used for each batch. Since they were from different premix suppliers, the vitamin C and vitamin A sources were different as well.

The WSB sent to Haiti with the conventional level of vitamin C showed a vitamin C retention of 87% after nine months, which is significant (P<.01) but does not indicate a large enough loss to be concerned about. The WSB with the high level of added vitamin C showed a small gain, but it was not significant (P>0.05), so the conclusion would be that no vitamin C was lost in this product after nine months of storage.

The samples of CSB collected in India, which contained conventional levels of vitamin C, came mainly from two lots (AA and AB) produced on the same day. The mean vitamin C in those samples compared to the production mean of the same two lots showed a very slight gain that is not significant (P>0.05). Again, the conclusion would be that no vitamin C was lost in dry CSB after five months.

There were significant (P<0.01) losses of vitamin A in both WSB and CSB. WSB showed a vitamin A retention of 62% after nine months and 86% in the CSB after five months. These losses were much greater that the changes shown by the same samples under frozen storage, so the losses are due to field storage conditions. There was no difference in the retention of vitamin A in WSB with the two different premixes (the one with the conventional vitamin C level and the one with the high vitamin C level). The main determinant of vitamin A retention appears to be the length of storage, although it may be that vitamin A is more stable in CSB than it is in WSB, a conclusion supported by the frozen storage studies.

Table 12. Vitamin C and A Retention in CSB and WSB Based on Comparison of Mean Levels

		Vitamin C Means			**Vitamin A Means**		
Product	Lots	at plant	at recipient	Retention	at plant	at recipient	Retention
		(mg/100g)	(mg/100g)	(%)	(IU/100g)	(IU/100g)	(%)
WSB	Conventional C	42.7	37.1	**** 87.0%**	2954	1820	**** 61.6%**
WSB	High C	76.2	79.7	NS **104.6%**	2410	1578	**** 65.5%**
CSB	lots AA & AB	38.4	39.4	NS **102.7%**	2165	1854	**** 85.6%**

** Significantly different from 100% retention at P<0.01 indicating loss.
NS Not significant different from 100% retention at P>0.05 indicating no change.

Table 13. Vitamin C and A Retention in WSB Based on Comparison of Paired Samples

Lots	Vitamin C Means at plant	at recipient	Retention	Vitamin A Means at plant	at recipient	Retention
	(mg/100g)	(mg/100g)	(%)	(IU/100g)	(IU/100g)	(%)
Conventional C	42.9	37.5	**** 87.6%**	2881	1830	**** 63.5%**
High C	75.9	80.0	NS **105.4%**	2419	1589	**** 65.7%**

** Significantly different from 100% retention at P<0.01 indicating loss.

NS Not significant different from 100% retention at P>0.05 indicating no change.

Stability of Vitamins in Frozen Samples

The results show little change in vitamins during frozen storage. There was no significant loss of vitamin C in CSB after five months storage or in WSB after nine months, nor was there any loss of vitamin A in CSB. There was a small but significant (P<0.05) loss of vitamin A in WSB after nine months storage.

Table 14. Vitamin Retention in Frozen Samples

Product	Storage Time	Vitamin C Means at Production	after Freezing	Retention	Vitamin A Means at Production	after Freezing	Retention
	(months)	(mg/100g)	(mg/100g)	(%)	(IU/100g)	(IU/100g)	(%)
WSB	9	53.9	54.2	NS **100.6**	2651	2448	*** 92.3**
CSB	5	39.0	37.1	NS **95.2**	2143	2244	NS **104.7**

* Significant different form 100% retention at P<0.05 indicating small loss.

NS Not significant different from 100% retention at P>0.05 indicating no change.

Vitamin A Stability in Wheat Flour

The vitamin A stability in wheat flour was shown by this study to be surprisingly good. There was virtually no loss of vitamin A after nine months of storage.

Wheat flour samples were collected at a CARITAS warehouse in Lima, Peru, and at the FHI El Alto warehouse in La Paz, Bolivia. Full results are shown in Appendix D. In Peru multiple samples were taken from three different lots. Vitamin A content was compared to that of the retained FGIS samples for each lot, as shown in the following table. The small drop in vitamin A was statistically significant at the 5% level for one lot but not the other two. There was only a one month period between the time of testing the retained FGIS samples and those collected at the recipient sites.

Table 15. Vitamin A Retention in Wheat Flour in Peru

Lot	Number of Samples	Vitamin A Means (IU/100g) FGIS	at recipient	Retention
12	5	1406	1570	*** 89.6%**
13	3	1290	1350	NS **95.6%**
14	5	1242	1340	NS **92.7%**

* Significantly different from 100% retention at P<0.05 indicating loss.

NS Not significant different from 100% retention at P>0.05 indicating no change.

Table 16. Vitamin A Retention in Wheat Flour in Bolivia

Contract	Number of Samples	Vitamin A Means (IU/100g) FGIS	at recipient	Retention
1624	18	2086	2023	NS **97.0%**
1635A	11	1731	1763	NS **101.8%**
1635B	25	1672	1646	NS **98.5%**

NS Not significant different from 100% retention at P>0.05 indicating no change.

Two contracts of wheat flour were found in Bolivia. They had been there for a considerable amount of time since the time between testing the retained FGIS samples and the samples collected in Bolivia was nine months. Surprisingly, there was virtually no loss of vitamin A in that period, as shown in Table 16, which compares the vitamin A content in matched lots of product. The large number of samples (54 total) involved in this analysis gives a high level of confidence to these results.

Vitamin A Stability in Bulgur

The vitamin A stability in dry bulgur appears to be acceptable, but the data collected in this study is not as convincing as it is for wheat flour because it only covered a one month storage period and involved very low levels of vitamin A in the products out of the plant.

Same-lot samples of one bulgur contract produced by plant G, as indicated by the same production date stamped on the bags, were collected at the CARITAS warehouse in Peru. These were collected in two sets: seven from one pallet and 14 from different locations around the warehouse. There was a large variability in the vitamin A results on the first set of 7 samples, ranging from a low of 780 IU/100g to a high of 3510 IU/100g. The second set was more uniform. The vitamin A retention was 135%, an increase, but this was not statistically significant because of the high variability. Removing the first set, the retention was 116% but this was not significant.

Six samples from two lots of another bulgur contract produced by plant L were collected from the CARITAS warehouse. The vitamin A content of this contract was very low to begin with making it more difficult to determine loss. Also, while there were vitamin A results on FGIS samples from this contract, they were not from these lots. In comparing the results from the Peru samples which averaged 613 IU/100g to the six FGIS lot samples, which averaged 514 IU/100, there was a vitamin A retention of 119% which is not statistically significant. This indicates there was no loss of vitamin A in these samples.

Samples of bulgur were collected at two different warehouses in Bolivia. All were from the same contract produced by Plant L. Vitamin A levels on this contract as determined by the retained FGIS samples were very low, only a quarter of the minimum specification. The mean vitamin A content of the 16 collected samples was virtually the same as that of the retained lot samples, indicating no loss after nine months.

Conclusions

This study shows that the low levels of vitamins found in fortified P.L. 480 food commodities at recipient sites overseas by Atwood et al (3) were largely the result of the commodities having low levels of vitamins at the start. While there was some loss of vitamin A in WSB after nine months, showing a 63.5% retention, there was little loss of vitamin A in wheat flour and bulgur or vitamin C in CSB and WSB during shipping and storage.

This may be due to the fact that the vitamin A particles most susceptible to oxidative destruction, those with a poor coating, are destroyed early on during manufacturing. The remaining particles are better protected and have better stability. This could account for the observed drop in vitamin A during production and the good stability afterwards.

There is an interesting connection between plant B making WSB, plant F making flour and plant L making bulgur. All three plants are supplied by the same fortification premix supplier, which did not provide premix to any of the other production sites sampled in this study (except for plant A where the vitamin A content was not tested because of the wide variability). Vitamin A levels in the bulgur and flour were low. This may be due to the poor quality and stability of the vitamin A used by both plants. Both plants were pneumatic systems, so the vitamin A may have been lost to oxidation when it came into contact with air in the mill. There was no loss of vitamin A in plant B, however, which uses a gravimetric batch system and thus gives limited exposure to the vitamin A in the mill. The WSB from plant B did show vitamin A loss during subsequent handling and shipping. This loss might then be due to the WSB product having been fortified with a poor quality vitamin A product. The WSB may not have shown the same degree of loss if it had been fortified with the same source of vitamin A used in the CSB products.

The conclusion from these results is that vitamin loss in the dry commodities is statistically significant, but it is not a serious overall problem. The one-third loss of vitamin A found in WSB nine months after production was the largest loss observed, but this level of loss is within the expected vitamin A loss endured by the US food industry. WSB makes up a relatively small proportion of processed food aid, and the problem probably could be remedied by the manufacturer using a more stable source of vitamin A. There is no need to change the packaging, lower the moisture content or implement any of the related actions that have been proposed. Any such action would likely be expensive and ineffective. The one action recommended is that the mills and premix manufacturers make sure the vitamin A they use is of good quality and meets the stability standards specified by the USDA.

D. Stability of Selected Micronutrients During Food Preparation

Overview

The final concern regarding micronutrient fortification of P.L. 480 food aid commodities is that the added vitamins survive the cooking processes typically used by the recipients. Laboratory studies were run on typical food preparations of CSB and WSB to become familiar with their cooking properties and to estimate levels of expected vitamin losses. This was followed by field studies to determine the retention of vitamins A and C during normal food preparations of CSB and WSB as a normal part of Title II programs in two countries.

Laboratory Studies

It was noticed in the laboratory trials that the same concentration of WSB is initially thicker than CSB in cold water, but that during cooking the CSB thickens more than WSB does. This is probably because CSB is less fully gelatinized than WSB, which makes CSB a little easier to prepare since the mixing during cooking is not as difficult. Cooked CSB had a milder taste than WSB, which can have some bitterness due to the wheat protein concentrate.

The retention of the vitamins C and A in the food at various stages of cooking and holding times are shown in Appendix D. These were calculated from the amount of vitamin that was present in the CSB or WSB corrected for its dilution.

WSB showed a vitamin C loss of approximately one-third just from the addition of water. **The final retention of vitamin C in the WSB gruel and paste was 70% to 50%.** CSB showed a higher vitamin C retention in beverages and gruel of around 85%. The WSB dumplings showed a lower vitamin C retention, similar to what was found in the field studies, and a steady loss over cooking time. This suggests that the water-soluble vitamin C is leached out during cooking. The vitamin C lab retention levels were higher than those found in the field studies. There are many differences between the field and laboratory conditions that may account for this, one being the rapid freezing of the laboratory samples compared to those in the field.

A second set of tests was run to determine the effect of simply wetting the CSB/WSB. The results, shown in Appendix D, do not indicate much of an effect but heating the wetted material resulted in a final vitamin C retention of around 88%.

Cooking Methods Observed in Field Studies

These studies were conducted in Haiti where WSB was prepared at home and in refugee camps in Tanzania receiving CSB. All preparations were cooked in an aluminum pot over charcoal or a wood fire. All dishes had a pH of 6, with two exceptions where the pH was 7.

Gruels: Gruel is the most commonly prepared food observed for both CSB and WSB, accounting for 24 out of the 59 samples collected. On average, 14 grams of CSB or WSB are used per 100g of liquid to prepare gruel. Table 18 summarizes the vitamin C and vitamin A retention in the cooked food samples. A typical gruel was prepared by simply boiling CSB or WSB in water. The CSB/WSB was normally mixed with a portion of cold water to form a slurry while the rest of the water was brought to a boil. The slurry was then added to the boiling water and stirred. The mixture was brought again to a boil and allowed to simmer for a few minutes. The normal total cooking time for WSB gruel was 19 ± 5 minutes in Haiti and 12 ± 6 minutes for CSB gruel prepared in the refugee camps (cooking times are shown as the mean ± one standard deviation).

Dumplings in Haiti: These dough dumplings, made of WSB and salt water, were shaped like fingers and then added to a vegetable broth, sometimes with meat or fish. The normal total cooking time for WSB dumplings was 18 ± minutes. For the sampling of this dish, the dumplings and vegetable broth were added together in one pot. However, the dumplings were collected as samples without vegetable or broth.

Ugali in Tanzania: Ugali is a stiff paste comprised of CSB and water that accompanies another dish called sauce. The sauce is usually prepared with beans and vegetables such as tomatoes, onions and cabbage. To make ugali, a small amount of water was brought to a boil. A portion of this water was removed just before it reached the boiling point and mixed with the CSB in another bowl into a thick dough. This dough was added to the boiling water and stirred for a few minutes to form a dry thick paste. The average total cooking time for CSB ugali was 5 ± 1 minutes.

Table 17. Summary of Food Preparation Samples Collected in Selected Countries

WSB in Haiti	Number of Samples	CSB in Tanzania	Number of Samples
High vitamin C	5 Gruel 5 Dumplings	High vitamin C	7 Gruel 4 Ugali
Conventional vitamin C	4 Dumplings 3 Gruel	Conventional vitamin C	9 Gruel 1 Ugali

A batch of CSB was fortified with higher vitamin C level (90 mg/100g) than the conventional level added (40 mg/100g). Rather than one level of 90 mg/100g, the CSB used for the food preparation had four levels of fortification (68, 93,140, and 160 mg/100g). The unexpected wide variation in the levels of fortification indicated a uniformity problem with fortification at the U.S. processing plants. It also provided the opportunity to determine the effects of different concentrations of vitamin C upon vitamin C retention in CSB after it was cooked in the field.

Retention Levels in Cooked Foods

Large losses of vitamins C and A in both CSB and WSB occurred during normal food preparations. Retention levels are presented in Table 18. Vitamin C retention in the gruel, dumplings and ugali samples averaged 30% for the WSB and CSB with the conventional level of vitamin C. For the commodities with high levels of vitamin C, the vitamin C retention averaged 58% for CSB and 55% for WSB.

Five out of nine gruel samples made from CSB with the conventional vitamin C levels showed vitamin C content to be below the level of detection of 1 mg/100g. The magnitude of the vitamin C loss for CSB was inversely proportional to concentration: the higher the level of vitamin C in the dry commodity before cooking, the greater the retention. This would be explained by the fact that vitamin C is less stable in diluted solutions than in more concentrated ones, particularly at pH 7 (4). The type of preparation did not have a significant effect on the vitamin C retention for WSB and for CSB preparations with high level of vitamin C.

Table 18. Vitamin A and Vitamin C Retention during Food Preparation

Commodity	Vitamin C level	Preparation type	N	Vitamin C	Vitamin A
				Average percent retention	
Corn Soy Blend	Conventional	Gruel	7	25%	46%
		Ugali	1	51%	83%
	High	Gruel	6	58%	47%
		Ugali	4	55%	89%
Wheat Soy Blend	Conventional	Gruel	3	27%	46%
		Dumpling	4	18%	65%
	High	Gruel	5	32%	46%
		Dumpling	5	33%	77%

As expected, vitamin A had better retention than vitamin C during cooking. The vitamin A retention averaged 46% for the gruel samples and 70 % for the ugali and dumplings. The retention of vitamin A was significantly ($p< .01$) better in the drier ugali and dumpling preparations than in gruel with higher moisture content.

The reported time variables were 1) the time that the commodity spent in a slurry comprised of the commodity and 2) water before cooking and the cooking time. They did not have significant effect (P>0.10) on the retention of either vitamin C or vitamin A.

Conclusions

Large cooking losses of vitamin A and vitamin C were found during normal food preparation procedures used on CSB and WSB. One-third to one-half of the initial vitamin C content was retained. Less than one-half of the initial vitamin A content was retained during preparation of gruel, the most commonly used preparation to feed young children. A better retention of vitamin A (70%) was observed for drier preparations (ugali and dumplings).

These large cooking losses are not unexpected. They are in line with past studies on similar cooking methods. The results make evident the need for more stable forms of vitamin A and C that are better able to withstand cooking. There are heat stable vitamin C products available but they have not been tested in CSB and the best ones have yet to be approved for human consumption. Currently, there is no form of vitamin A available that has a better cooking stability than the 250SD type product currently specified, but there are probably differences in the stability of the different commercial forms that are being used.

Food companies would not add vitamin C to products similar to CSB that are normally cooked, recognizing that most of the vitamin would be destroyed. Instead, they add it to foods like ready-to-eat breakfast cereals and fruit juices where vitamin stability is less of a problem since they involve no cooking. This is not an option with P.L. 480 commodities currently supplied to food aid programs, since they all have to be cooked. The one exception is instant corn soy blend. It contains fully gelatinized corn meal so it could be prepared by mixing with warm water. This product has been developed but is not in current use. This could be a result of the concern of possible contamination if the water used is not potable or not boiled.

It may be that foods such as CSB and bulgur, which are cooked in water, are not the best vehicles for delivering vitamin A. There is probably better vitamin A retention in wheat flour, which is made into bread. A better vehicle is vegetable oil when used as an ingredient in salad or at low or moderate cooking temperatures, so it makes good sense to have it fortified with vitamin A. The way most food companies address the problem of vitamin A losses is to simply add additional vitamin A to ensure that the surviving vitamin meets desired levels. This may not be the best approach with P.L. 480 commodities where economics is more of a constraint. Until a more stable form of vitamin A is developed, the best policy would be to keep fortifying all the P.L. 480 commodities at current vitamin A levels and grudgingly accept the fact that half of it will be lost during cooking.

V. RECOMMENDATIONS & IMPLICATIONS

A. Meeting Micronutrient Levels During Production

A1. Monitor and enforce minimum micronutrient specifications currently applicable to processed fortified P.L. 480 cereals.

Fortified P.L. 480 processed foods, which do not include the blended foods CSB and WSB, have minimum, end-product fortification standards that are not being monitored or enforced by the USDA. These standards are similar to those for enriched cereals, under enforcement by the Federal (FDA) and state food regulatory agencies, except for the requirement of added vitamin A and calcium in Title II foods. The MAP activity uncovered a number of cases where fortified P.L. 480 food commodities failed to meet these minimum levels, particularly with vitamin A in wheat flour and bulgur.

Monitoring fortification levels in processed foods would involve the USDA FGIS testing a selected micronutrient indicator (discussed in Recommendation #A3) in all or some of the official lot samples and taking appropriate action if a producer was continually outside of specifications.

The direct cost of this monitoring is the cost of analytical testing. For a single vitamin A or niacin assay, this would cost $50 per test of an FGIS lot sample[10]. For a two-railcar lot of 135 MT, this would cost $0.37/MT, or about 5% of what it costs to fortify these commodities. There would be no additional sampling cost. While the USDA FGIS laboratory would perform this test, the cost of the testing would be reimbursed by the processing plant and reflected in their bid price, as is done under current procedures for other analytical testing. The cost would then be added to the cost of the commodity rather than have to be paid directly by the USDA. It would then proportionally reduce the amount of commodity that USAID could purchase, or a reduction of approximately 0.26%.

A secondary cost of this monitoring is any additional expense manufacturing plants would incur to ensure they conform to the standards. The MAP study revealed large differences between plants in their ability to meet specified minimum levels and maintain a uniform product. Enforcement of the micronutrient standards would motivate some plants to improve their operation and quality of the premixes they use. Investments in improvements by such plants might put them out of the competitive bid range. Some may choose to drop out of the program if they can not consistently meet the standards; others may have to be decertified by the USDA. This would reward those companies accomplished at fortification while penalizing those plants that were not. The end result may be a small increase in the average bid price of these commodities, since the low-cost producers would have increased costs or be fewer in number.

The MAP study showed that bulgur from one plant had one-quarter of the amount of vitamin A it was expected to have. Since the government was charged $5.96/MT to fortify bulgur with vitamin A, for every MT of bulgur shipped, the government was incurring a loss of $4.47/MT. Product monitoring in this case would have cost only $0.37/MT to recover $4.47/MT, a worthwhile investment.

The long term implication of monitoring and enforcement of current micronutrient standards would be to increase in amount of micronutrients, particularly vitamin A, actually delivered to food aid recipients. This should increase the nutritional health of the food aid recipients as regards vitamin A status, considered a major goal of the USAID. Implementation of such monitoring and enforcement should be possible by the end of 1999.

A2. Establish, monitor and enforce a minimum, end-product vitamin standard for one vitamin and one mineral in fortified blended foods (CSB and WSB).

Currently, the only regulations on the fortification of blended foods (CSB and WSB) are process standards in that they specify only the amounts of vitamins and minerals to be added to the commodity and not the levels in the final food. There are no minimum specifications for any of the micronutrients in the final blended food product, as there are for the fortified processed foods. There is no mechanism to ensure that the commodity has been properly fortified. The MAP activity revealed a couple of cases of low vitamin A levels in CSB while subsequent testing by the USDA showed many lots of CSB from some plants were low in a number of micronutrients including vitamin A.

[10] Analytical test charges at the FGIS laboratory are $50 for vitamin A, $50 for niacin, $15 for iron and $20 for zinc.

USDA should use the current addition levels as the specification standards for all added micronutrients in blended foods, as given in Table 3. As described in Recommendation #A3, USDA should establish a minimum standard for one vitamin and one mineral as the micronutrient indicators, and monitor all lots using these vitamin and mineral "indicators" in order to ensure blended foods are properly fortified. This should result in shipped CSB lots being closer to target micronutrient levels along with improving the uniformity of micronutrient levels, providing more constant delivery of added micronutrients to the food aid recipients of blended foods.

With two tests, one for vitamins (vitamin A or niacin) and one for minerals (iron), the added cost would be $65 per lot, or $0.48/MT of CSB/WSB at 135 MT/lot. As with recommendation #A1, the added expense would be paid by the manufacturer and be reflected in a higher bid price for the commodity. This recommendation could be implemented by the end of 1999.

A3. Establish vitamin A as the micronutrient indicator for all P.L. 480 processed fortified cereals. In processed fortified and blended foods (CSB and WSB), establish vitamin A as the vitamin indicator and iron as the mineral indicator.

It would be costly and impractical to test for minimum specifications for all the micronutrients added to blended foods on a routine basis. A better approach would be to use one vitamin as an “indicator” to establish whether a product has been adequately fortified. Since this vitamin would be a component of a premix, and since the composition of the premix could be verifiable by independent means as described in recommendation #A5, compliance of a single vitamin indicator would indicate that fortification with the other vitamins and minerals added through the same premix was proper as well. Usually the most vulnerable vitamin is selected to assure that all nutrients meet established standards.

To arrive at the recommendation on indicators and allowable variation, the policies and practices of related industries were consulted. Infant formulas are under the regulations of 21CFR107 of the U.S. Food and Drug Regulations. This requires a certain minimum and, in some cases, a maximum level of specified micronutrients. The required practice is that every added micronutrient must be tested by the manufacturer and the FDA in every lot of product and must not be lower than 10% below the label claim. Nutrient indicators are not used in infant formulas since the level of each micronutrient is tested separately. To achieve the minimum, the manufacturer normally adds excess nutrient, while staying below any stated maximum.

Animal feed manufacturers do allow and use micronutrient indicators. These manufacturers also publish analytical variations (AV)[11] for each micronutrient and other feed components (5). AVs are guidelines for helping control officials make decisions on the acceptability of a product. Their AVs for the proposed indicators are: vitamin A ±30%, niacin ±25%, iron ±25% and zinc ±20%. Thus, corrective action would not normally be taken if a lot was within -30% of the label claim.

Current U.S. regulations on the nutritional labeling of foods for human consumption under 21CFR also provide guidance on regulation for micronutrient fortification. The regulation states two classes of nutrients: class I, where the nutrient is added to a food and, class II, where the nutrient is naturally occurring in the food. If a nutrient is added, even though it is also naturally occurring, the nutrient is classified as class I. Since all nutrients under

[11] According to the Association of American Feed Control Officials, Inc., Analytical Variations (AV’s) are guidelines for helping control officials make routine decisions on acceptability of products appearing to be marginally acceptable. AV values are not intended to allow real deficiencies or excesses of the guaranteed ingredient. They are not intended to cover sloppy work, poor sampling, or any deficiency in analytical or clerical procedures. They allow only for the inherent variability in laboratory analyses. Manufacturing variations are not included in the AV values, which are generated from check sample data involving two determinations on separate days in a laboratory operating under normal working conditions. Replication of the assay will increase the analyst’s confidence. However, replication in a laboratory only reduced the within-lab component of the total variance. Consensus of two or more independent laboratories reduces the between-lab variation, or bias. The between-lab variance is usually larger than the within-lab variance. The choice of using two coefficient of variation (COV) to determine the recommended AV is an arbitrary one. Using two CV means a 95% confidence limit. The risk of rejecting a satisfactory lot based on these AV’s is one chance in 40. Assay values farther from guarantee will carry less risk. AV’s are intended to apply to individual determinations made under routine conditions on a single sample. A history of seven or eight samples of a given product, each of which is found slightly deficient as much as the AV, is ample justification for the control official to take action.

consideration here are added nutrients, they would strictly be subject to the regulations governing class I nutrients. For all class I nutrients, the value for that nutrient should be at least equal to the label claim.

> (g)(4)(i) *Class I vitamin, mineral, protein, dietary fiber, or potassium. The nutrient content of the composite is at least equal to the value for that nutrient declared on the label.*

The regulation for class II nutrients is the following.

> (g)(4)(ii) *Class II vitamin, mineral, protein, total carbohydrate, dietary fiber, other carbohydrate, polyunsaturated or monounsaturated fat, or potassium. The nutrient content of the composite is at least equal to 80 percent of the value for that nutrient declared on the label.*

Under this regulatory climate, it would appear prudent and reasonable to set the minimum compliance standard at 80% of the added level for vitamin A, which would allow for normal variability in sampling and the analytical method used to assay vitamin A.

Vitamin A is a most sensitive indicator because there is no vitamin A naturally present in these commodities; any vitamin A found could not be confused since no amounts are naturally present. Also FDA commonly used vitamin A because it is unstable, so when its level is in compliance the levels of more stable added vitamins are also likely to be in compliance. The standard also allows for normal variation due to sampling and testing. Vitamin A is an important micronutrient nutritionally, and also accounts for a large proportion of the cost of fortifying these commodities.

Since the minerals are added separately to CSB and WSB, a separate mineral indicator would be needed for the blended foods, unless a combined mineral/vitamin premix were allowed, as recommended in #B2 below. This would be a choice between iron and zinc. **Iron is recommended for use as a general indicator because of its nutritional importance and the advantage it has in being added to all fortified P.L. 480 food commodities, as opposed to zinc, which is added only to CSB and WSB**.

The minimum levels for iron, zinc or niacin, the other indicators investigated, should meet the target levels (100% of what is specified to be added), as given in Table 3. The large natural content of these three micronutrients in CSB and WSB provides a margin of error above the required level. They are also quite stable.

The indicator for the fortified processed P.L. 480 food commodities would be either vitamin A or iron, with the minimum standard the current minimum shown in Table 2 for the different class of foods. Only one micronutrient indicator need be tested since only one premix is used in these commodities (a combined vitamin/mineral premix). Vitamin A is recommended here as the indicator of choice as opposed to iron, for the same reasons discussed above. The minimum vitamin A level required in all fortified processed foods would be the current vitamin A minimum standard of 2205 IU/100g.

USAID and USDA have already started evaluating suitable micronutrient indicators through SUSTAIN's Food Aid Secretariat, as described in the Accomplishments Section. Four possible micronutrient candidates were selected jointly by USAID and USDA for the fortified blended foods (CSB and WSB), as shown in Table 19: vitamin A or niacin for the vitamin premix; zinc or iron for the mineral premix. A minimum vitamin A compliance minimum level of 1850 IU/100g was proposed because it is 80% of the current target and there is no vitamin A naturally present in these commodities. The 20% difference between the target and the minimum specification is in agreement with that used by the FDA, as described above. It allows for normal variation due to sampling and testing. The minimum levels for niacin, iron and zinc were taken at the target levels since there is a large natural content of these three micronutrients in CSB and WSB.

The natural content of these three micronutrients was not tested in the MAP study. However, results for niacin, shown in Figure 3, and for iron, in Figure 4, show that the levels of these two micronutrients in normally fortified products are well over the levels added, while vitamin A (Figure 1) and vitamin C (Figure 2) levels from these same plants are much closer to the added level. This difference results from the large natural content of these two micronutrients. Zinc was not tested in the MAP study, but it was tested in CSB by a separate USDA study (6) where high zinc levels similar to the iron levels found in MAP were found.

These four nutrients were selected by the USDA and USAID for a pilot evaluation as possible indicators due to their ease of assay and commonality in the different P.L. 480 fortified products. Some micronutrients are easy to analyze (vitamin C, pyridoxine) but are added only to blended foods. Other vitamins, such as folic acid, are added to all the fortified commodities but are very difficult to test for and as a result were not considered as possible indicators. A relatively inexpensive nutrient, such as iron or thiamin, would be less desirable as a micronutrient indicator for a combined vitamin and mineral premix since it could be added in excess without incurring much additional cost, while allowing the more expensive nutrients, like vitamin A, to run low. very high, but somewhat variable, natural levels of niacin in CSB and WSB[12]. This study found that target niacin levels were easily achieve

There have been questions raised as to the appropriateness of niacin as an indicator because niacin levels were adequate even when vitamin A and vitamin C levels were low or marginal, as shown in Figure 3. There is no difference in the cost of running vitamin A and niacin assays, as charged by the FGIS laboratory. Both are run on the same equipment, a high-pressure liquid chromatograph (HPLC).

One concern with using vitamin A as an indicator, as suggested by the results of this study, is that it could be oxidized and lost during addition at the mill. Low levels of vitamin A would not necessarily indicate low levels of the more stable micronutrients that were added in a premix along with vitamin A. Loss of vitamin A during processing is a serious problem that the premix manufacturer and the processing plant can correct, as shown by the experience at one of the bulgur plants. Monitoring of vitamin A levels would encourage all plants to take similar corrective actions if loss of vitamin A was found to occur.

A4. Remove all maximum standards on micronutrients and/or enforce minimum standards only in P.L. 480 processed cereals.

Table 2 shows that some of the fortified processed P.L. food commodities have both minimum and maximum standards. A single minimum standard with overages left to "good manufacturing standards," as used with wheat flour, is the preferred regulation by the FDA on micronutrients. Maximum levels serve no useful purpose. Manufacturers will not deliberately add excessive amounts of vitamins since it costs them money. There will be rare occasions when fortification will be high, but having a maximum level will not prevent that from happening.

This study showed that the current ranges are too narrow to be achievable. They are about the same size as the assay error, so it is unrealistic to expect manufacturers to stay within them. Removing the maximum or enforcement of the minimum only will save money by reducing the number of lots that would have to be rejected. If maximum standards are removed, some vigilance needs to be retained of any evidence that fat soluble vitamins or some minerals, such as iodine, are exceeding safe limits on a consistent basis.

A5. Bulgur and wheat flour producers, especially, working with fortification premix producers, need to correct the problem with low vitamin A levels found in their commodities.

This study showed a serious problem with low levels of vitamin A in bulgur and wheat flour at the point of manufacture. It is the responsibility of the mill, working with premix manufacturers, to take necessary steps to prevent this from happening. This might involve the mill taking the following actions:

- Request regular certificates of analysis (COV) on vitamin A activity in the premix lots, something not currently being provided by all premix manufacturers.
- The premix manufacturer should include an adequate overage of vitamin A that ensures it meets label claims within the stated shelf life of the premix.
- Maintain good storage of the premix to protect from heat.
- Use FIFO (first in, first out) inventory control and other logistical measures to ensure premixes are used within a month of receipt.
- Maintain feeders and associated equipment in good working order. Replace or repair worn feeders.
- Run daily check weights on feeders and adjust to product flow as necessary.
- Run regular premix inventory control and match against production figures to make sure the proper amount of premix is being used.
- Keep amount of air suction on product after it has been fortified to a minimum and check dust filters to make sure excessive levels of vitamins are not being removed. (This can be done with a UV light test for riboflavin.)

[12] The niacin test proposed by the FGIS laboratory is for *free niacin,* which would eliminate some of the concerns in using niacin as an indicator. In that case the minimum niacin level should be set at 4.0 mg/100g or 80% of the level added.

There should not be any major costs incurred by the government in order for manufacturers to implement these suggestions. The result of such implementation would be that vitamin A levels in fortified P.L. 480 food commodities would meet or come closer to target levels allowing more vitamin A to be delivered to food aid recipients.

B. Meeting Micronutrient Uniformity at Production Level

B1. Incorporate micronutrient fortification in the Total Quality Systems Audit (TQSA)

USDA is current investigating utilizing a Total Quality Systems Audit (7) as a way to maintain quality in all P.L. 480 commodities. This would partly replace the final product testing system now in place. TQSA incorporates many of the quality principles and procedures in current use by the U.S. food industry. It focuses on the quality of the manufacturing process, rather than the finished product characteristics. TQSA places responsibility on the producers themselves to prove they have the capability of continually and consistently producing a quality product.

If the TQSA system is established, it should include auditing micronutrient fortification capabilities and practices. For example, in order for a plant to be certified to make fortified P.L. 480 commodities they would first have to demonstrate their ability to produce a quality, uniform product according to the procedures described in TQSA. They would be required to regularly monitor the composition and usage of the fortification premixes. TQSA is a reasonable and practical way to control and improve the poor plant uniformity within lots observed in this study by some of the producers. Inclusion of a micronutrient component in a TQSA program should not result in any additional cost.

B2. Consider allowing combined addition of vitamins and minerals to CSB and WSB.

Current specifications require that a separate vitamin premix and mineral premix be added to blended foods (CSB/WSB) due to concern that the vitamins may not be stable when combined with certain minerals. There is no evidence that that is the case. Premix suppliers routinely mix vitamins and minerals with no degradation in shelf-life. The problem with having separate premixes for CSB/WSB is that some of the minerals are very fine in particle size (zinc sulfate, magnesium sulfate) and some are very coarse (sodium chloride, ferrous fumarate). The mineral (or salt) premix used to fortify CSB was observed to undergo physical separation during feeding in some plants. Another plant mixed the two premixes without a problem. There is no reason to require the two premixes be separate. Rather, it should be left up to the premix manufacturers and food producers to decide what micronutrients are best added as one premix, and which ones should be added separately.

This recommendation would not add an additional cost to blended foods fortification and could result in considerable savings. If iron and zinc were included in the vitamin premix, using vitamin A as an indicator would encompass those two minerals as well as all the vitamins. Implementation of this recommendation could result in lower costs and better uniformity of the micronutrients in CSB and WSB.

B3. USAID and USDA should help facilitate technical assistance to manufacturers of fortified P.L. 480 commodity producers on how to improve compliance and uniformity of micronutrient addition.

The MAP study revealed a number of instances of poor compliance and uniformity in micronutrient fortification of P.L. 480 commodities. Some of the companies involved are large, technically astute operations, while others are smaller companies with limited experience in food fortification. All of these companies may benefit from the observations and lessons learned in the course of this activity. USAID could identify sources of technical expertise for plants requesting such assistance. This should allow improved uniformity and compliance to standards by all plants, regardless of size.

C. Improving Stability of Added Vitamins

C1. Enforce the current stability specifications on the vitamin A required in fortified P.L. 480 commodities. The current stability specification on the type of vitamin A that must be used in fortified foods requires that it show no more than a 20% loss under specified conditions. The USDA should routinely request documented proof from the food producers that their vitamin premix suppliers are using vitamin A meeting the stability criteria. This could be done as part of the TQSA program in Recommendation #B1.

Such enforcement would not only restrict companies from using poor quality vitamin A, but would also reward those who have been using the higher quality material with better stability. Enforcement of this provision may also encourage development of new vitamin A products with higher stability, both in the dry product and during cooking.

The cost to the government in implementing this recommendation would be minimal. However, some companies currently using low cost vitamin A of inferior quality would have to use a more expensive product resulting in higher manufacturing costs that would be reflected in higher bids.

Implementation of this recommendation would result in lower vitamin A losses during manufacturing, shipping and storage of dry commodities, but probably would have little effect on improving the vitamin A retention during normal food preparation.

C2. Encourage mills and premix suppliers to improve vitamin A stability.

Mills should work with their premix suppliers to establish how much, if any, vitamin A is being lost in their system. The FGIS test results shown in Tables 9 and 10 suggest significant losses of vitamin A in wheat flour and bulgur. If the amount of the loss is high, there are three possible approaches that could be taken:

- Use a different, more stable form of vitamin A.
- Add additional vitamin A to account for the loss. This can be done by changing the premix composition or increasing the addition rate of the premix.
- Change the conveying after addition of the vitamins from a pneumatic to a gravimetric system.

The cost of implementing these changes will vary from plant to plant with those plants with the most problems incurring the greater expense. This would be reflected in a somewhat higher bid price from those companies. Implementation of this recommendation would increase the amount of vitamin A delivered to food aid recipients.

C3. Continue fortifying processed and blended foods with vitamin A.

The MAP study and related activities were instrumental in identifying specific losses of vitamins A and C due to cooking methods at distribution sites and in recipient homes. These losses were particularly marked in the preparation of gruels for weaning aged children. Despite the large loss of vitamin A found during normal food preparation procedures and the significant loss found in WSB after nine months of storage, it would be wise to continue the addition of vitamin A to these foods. The vitamin A remaining in the food as consumed is still of considerable benefit improving the nutritional health of millions of people.

Recognizing the reduced contribution of vitamin A from cooked processed and blended foods was one of the reasons vitamin A was added to refined, non-monetized, edible vegetable oil, as discussed in the Accomplishments section. This action, which was instituted December 1, 1998, helps ensure that recipients receive sufficient intake of this important nutrient from a P.L. 480 food basket despite the large cooking losses reported in this study.

C4. Investigate use of the more heat stable forms of vitamin A and C in CSB and WSB.

The MAP and Vitamin C Pilot studies showed significant losses of vitamin A and C due to cooking methods at distribution sites and in recipient homes. These losses were particularly marked in the preparation of gruels for weaning aged children. The retention of vitamin C may be improved by using some of the more heat stable forms currently on the market, as discussed in the report on the Vitamin C Pilot study (8). These include products with better coatings that are more resistant to loss during cooking, but also the polyphosphate forms now being used in aquaculture. USAID should collect more information on these products and investigate their stability in CSB/WSB during storage and in conventional food preparation procedures. If the polyphosphate forms are found to be the most cost-effective, USAID should explore obtaining GRAS approval for these products so that they can be added to foods. The additional cost of using these new forms of vitamin C in CSB and WSB will range from $0.50 to $4.00 per MT of commodity. The result of using vitamin C sources with increased stability in cooking would be the delivery of more vitamin C to food aid recipients and a small improvement in iron absorption.

While identifying a more stable vitamin A source for possible use in Title II foods is not as promising as it is for vitamin C, USAID should investigate what is available, particularly in the area of better coatings and antioxidant systems that can provide better protection during dry storage and cooking.

C5. Investigate precooked foods as an alternative means to deliver vitamin A and C to food aid recipients.

Because of the substantial loss of vitamins A and C during normal cooking of CSB and WSB, USAID and USDA should investigate alternate food delivery systems where cooking is not required. This could include precooked foods such as biscuits that can be eaten without any food preparation, or an instant, fully gelatinized CSB that can be prepared into a gruel by simply mixing with water. Similar foods are already being distributed to food aid recipients by WFP and some PVOs, so the technology involved in production is already established. A major task would be to establish the acceptance and cost-effectiveness of having a high value-added, fortified food available through Title II. These new foods must come with guidance and careful monitoring of their use because of the constant threat of gastrointestinal disease epidemics in emergency situations when potable water is not readily available.

C6. Include information on vitamin retention in the Commodity Reference Guide for use by field partners who provide food aid.

Most PVOs and other agencies distributing P.L. 480 fortified foods do not take into account normal vitamin losses during cooking in calculating food rations. USAID should make micronutrient friendly preparation methods available to these groups, through the Commodity Reference Guide or other guidance. This information should allow users to better determine the levels of nutrients actually being consumed by recipients, and it should recommend means to improve retention in cooking based on this study. For example, users should be informed of the higher vitamin retentions found when CSB is used to make ugali, or other preparations that use less water, as opposed to dilute gruel.

VI. ACCOMPLISHMENTS

A. Improvements in Fortification at the Manufacturing Plants

Prior to this study, both the FGIS and most plants producing fortified P.L. 480 commodities paid little attention to the vitamin and mineral fortification of the commodities. There had been no quantitative testing of the micronutrient levels in the FGIS sample. As a result there was no awareness of any problems with compliance or uniformity. The plants were very concerned with meeting stipulated regulations and specifications on these commodities, but not those regarding micronutrient content. Blended commodities such as CSB and WSB only have *process specifications* and USDA did not then have a micronutrient testing program in place to monitor micronutrient specifications. Most plant personnel were unaware of the critical importance the added vitamins and minerals in the commodities they were producing had on the recipients of the food. The SUSTAIN testing program heightened their awareness of the importance of micronutrients in the commodities and the need for improved quality control.

In the course of visiting these plants (with the full support and assistance of the FGIS), sampling the production and testing it for vitamins and minerals, most plant personnel and company management realized the need for application of the fortification premix correctly and uniformly. The process of sampling itself was an impetus for the plants to give more attention to what they were doing and to improve it where they could. The manufacturers of the vitamin and mineral premixes used to fortify these commodities were all informed of the MAP activity, and some were directly involved in providing premix assays and advising on plant fortification practices and problems. They would be an integral part of any continuing improvement process.

One example of this cooperation was the response by one manufacturer to serious problems found in the fortification of bulgur and soy fortified bulgur with vitamin A. The SUSTAIN testing detected both low values and a lack of uniformity for vitamin A in bulgur and soy-fortified bulgur. One bulgur producer (plant G) took a number of actions to solve this problem, including requesting and using a modified fortification premix. These actions resulted in considerable improvements in the final levels in the product. But there is still room for improvement since subsequent production continues to show low vitamin A content. Preliminary findings indicate that this could be due to oxidation although further testing would be needed to more fully determine the cause of the problem. The Quality Control Manager for the company owning bulgur plant L, which has the biggest problem in low vitamin A levels, was informed of the situation and is looking into possible solutions. The fact that USAID and USDA considered micronutrient levels important, as evidenced by their involvement in this study, was the trigger for plants to attempt to improve their fortification processes.

Vitamin A Fortification of Refined Vegetable Oil Used in Title II Programs

Providing vitamin A to deficit populations is an important program goal of the USAID. Because the MAP study revealed inadequacies in the present fortification program with vitamin A fortified Title II commodities, the need for an additional delivery system for this essential nutrient became evident. As a result, SUSTAIN commissioned a paper (8) on fortifying vegetable oil with vitamin A, which recommended that Title II oil be fortified to a level of 60 to 75 IU/g. This proposal was endorsed by an expert panel and presented to USAID for approval. USDA subsequently issued a revised specification requiring that all refined vegetable oil be fortified with vitamin A, effective December 1, 1998.

Maintenance of Vitamin C Levels in WSB and CSB

In 1996 Congress directed USAID to initiate a pilot program to increase the vitamin C content of blended Title II foods from 40 to 90 mg/100 g and report on the results. Since this issue related closely to the ongoing MAP research activities, SUSTAIN was commissioned to develop and conduct the pilot program (9), under a separate Cooperative Agreement with USAID's Global Programs, Field Support and Research Bureau, Center for Population, Health and Nutrition, Office of Health and Nutrition (G/PHN/HN). This involved setting up and monitoring special productions of CSB and WSB with enhanced levels of vitamin C, as proposed by the Senate and House Appropriations Committees, and evaluating those commodities at recipient sites overseas.

The protocol and results of this study were reviewed by a special *Committee on International Nutrition--Vitamin C in Food Aid Commodities* of the National Academy of Sciences (NAS), Institute of Medicine (IOM), which then provided recommendations to USAID on the advisability of increasing the vitamin C fortification levels of CSB and

WSB. The conclusion from this activity was that vitamin C levels in these commodities should not be increased as proposed, the current levels being adequate to prevent vitamin C deficiencies in food aid recipients (10). This resulted in a cost saving of approximately one million dollars annually.

B. Contribution to Quality Assurance Procedures

The MAP and Vitamin C pilot studies identified a need to monitor and ensure that end product micronutrient standards are being achieved. It was concluded that reliable vitamin and/or mineral “indicators” needed to be established in order to determine whether a product had been properly fortified. Working with USDA and USAID through the newly formed International Food Aid Commodity Secretariat, SUSTAIN recommended possible indicators and minimum specifications for consideration, shown in the following Table 19.

These recommended indicators were adopted and led to a plan whereby the FGIS lab would establish analytical procedures and test the first lot of each contract for CSB from all the different producers for these four nutrients. This initial testing was completed in February 1999, and the results are being evaluated. These are official USDA samples made up of multiple samples collected during production of a single lot of 4 to 6 hours. Composite test samples will not detect variations from bag to bag – only whether average values meet the specification target. Upon completion of the evaluation of the results the agencies will determine which indicator(s) should be used and how they will be enforced.

Table 19. Possible Minimum Levels of Possible Micronutrient Indicators for Processed Foods

Micronutrient	Minimum	Units
Vitamin A	1850	IU/100g
Niacin	5.0	mg/100g
Iron	14.7	mg/100g
Zinc	4.0	mg/100g

C. Enhanced Dialogue on Food Aid Commodities Initiated and Promoted Among Stakeholders

It became evident in the course of the MAP and Vitamin C pilot studies that there were a number of issues regarding the nutritional properties and quality of Title II, P.L. 480 commodities that necessitated continued cooperation and dialogue between USAID, USDA, the commodity manufacturers and the PVOs. Under a Cooperative Agreement with USAID/G/PHN/HN, and with funding from USAID/BHR/FFP, an International Food Aid Commodity Secretariat (IFACS) was established under SUSTAIN to address these issues. This Secretariat will continue working on solving problems uncovered in the MAP study along with investigating any new problems that come to light. Information dissemination regarding food aid commodities will be facilitated through the IFACS Commodity Reference Guide update and web page.

D. Updating the Commodity Reference Guide (CRG)

The Commodity Reference Guide (CRG) provides useful technical and policy information to PVOs and other interested parties on Title II, P.L. 480 commodities. The CRG has not been updated for ten years and so contains some outdated information. SUSTAIN is updating the CRG as part of the Food Aid Secretariat using some of the information obtained through the MAP activity. An Internet web site, <www.info.gov/hum_response/crg/ is being developed. This resource will make CRG information easier to obtain and keep current.

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APPENDIX A

Literature Review

PAST STUDIES ON UNIFORMITY AND STABILITY OF ADDED MICRONUTIENTS

Uniformity studies

Very few studies have been done on the uniformity of nutrients added to cereal products In one study on mill fortification (*1*), no evidence was found of separation of any of the enrichment components, including the magnetic "reduced iron", added to flour on a continuous basis at the flour mill All samples taken at the mill, during transport, at the bakery and in the final bread showed excellent uniformity, well within the standard error of the analytical methods used A separate study on flour passing by a magnet showed no difference in iron content before and after the magnet There was also no evidence of flour streaking, which is what would be expected if clumps of reduced iron were falling off the magnet No loss of vitamin E and the B vitamins was found in wheat flour subjected to normal bleaching and maturing treatments (*2*)

Vitamin A

Cereal Products

Both vitamin A and β-carotene contain a conjugated double bond system, making them susceptible to oxidation and reduction in vitamin A activity when exposed to air This process may be accelerated by heat, light, trace minerals and moisture Thus, vitamin A and β-carotene are considered inherently unstable during processing, storage and cooking of foods (*3*)

The effect of storage and cooking on added vitamin A palmitate in fortified cereal-based products has been studied by a number of investigators, whose results are summarized in the following table No losses of vitamin A activity were reported in vitamin A fortified flour when stored for 6 months at room temperature (*4-6*) With increased storage temperature, however, retention of vitamin A activity was reduced For example, 70% vitamin A retention was found in flour stored for 6 months at 26°C (*7*) while flour stored for 6 months at simulated warehouse temperatures (i e , 21-32°C) retained 89% vitamin A activity (*5*) Others studies have shown only 50% vitamin A retention in flour stored for 6 months at 37°C or 40°C (*7*)

Accelerated shelf-life tests have shown 12 weeks storage at 45°C may be used to predict vitamin A retention after 2 5 years storage at room temperature (*4*) Results from these studies (i e , 12 weeks storage at 45°C) found vitamin A retention in flour was 50% (*7*) and 71% (*4*) Thus vitamin A stability in flour is both time and temperature dependent Fortified flour stored for 6 month at room temperature retains nearly 100% vitamin A activity With increasing storage temperature, however, vitamin A retention decreases significantly

Vitamin A retention in cornmeal fortified with vitamin A palmitate has been investigated In one study vitamin A retention in cornmeal stored for 6 months at room temperature was 90% (*4*) and 98% (*8*) As found in flour increased storage temperatures reduced vitamin A retention Cornmeal stored for 6 months at 4°C 21-32°C and 40°C resulted in vitamin A retention of 85% 80% and 50% respectively (*5*) Accelerated shelf-life tests (12 weeks at 45°C) predict vitamin A retention in cornmeal after 2 5 years storage at room temperature to be 67% (*4*) Thus, under similar storage conditions, vitamin A retention in cornmeal appears lower than vitamin A retention in flour Like flour increased storage time and storage temperature reduces vitamin A retention

Vitamin A losses in foods prepared from cereal-based products fortified with vitamin A palmitate has been reported No loss in vitamin A activity was found in bread after baking in one study (*5*) while others reported vitamin A retention in baked bread to be 83% (*8*) and between 90-93% (*9*) An efficacy trial in

Jordan showed negligible baking losses in Arabian bread (*10*) In another study (*11*) on Persian *sangak* bread 68% of the vitamin A added to the dough with the yeast was recovered after the bread had been baked 2-3 min "Iranian fashion" on pebbles heated to about 204 C A study in the Philippines (*12*) showed 81% retention of vitamin A in flour after one month and 80% retention in the national bread, *pan de sal* After three months the retention was 54% in the flour and 32% in the bread

Vitamin A retention in other products such as corn bread and corn mush were 91% and 94%, respectively (*5*) Cornmeal preparation requiring 5 minutes cooking resulted in 87% vitamin A retention while corn grits preparation requiring 30 minutes cooking resulted in 66-75% vitamin A retention (*8*) In the extrusion of a corn/soy blend, 89% vitamin A retention was reported (*13*) Only 29% vitamin A retention was reported in extruded corn puffs made from corn flour while vitamin A retention in spaghetti made from semolina flour was between 80-90% after cooking (*14*) Thus cooking results in greater vitamin A losses in corn-based products than wheat-based products In addition, longer cooking times reduces vitamin A retention Work was done to fortify rice and whole grain products with vitamin A, but no stability data has been reported for such applications

β-carotene, like vitamin A, is susceptible to oxidation which results in reduced vitamin A activity The stability of β-carotene in cereal flours has not been reported β-carotene retention during baking was 80% in bagels and cake and 70% in cookies (*15*) Others report β-carotene retention during baking ranged from 85-96% in bread and 77-82% in crackers while no loss in β-carotene was found during typical product storage of bread after 7 days or crackers after 90 days (*16*)

A 1998 review of vitamin A fortification of wheat flour (*17*) concluded that vitamin A added to wheat flour was "sufficiently stable during storage under controlled conditions, and during cooking and baking of products made with fortified wheat flour "

In summary, studies indicate that vitamin A retention in cereal-based products fortified with vitamin A palmitate is dependent on time, temperature and the product Increased storage time and increased temperature reduces vitamin A retention in all cereal-based products Vitamin A retention in corn-based products, however, is lower than wheat-based products Baking appears to have little effect on vitamin A retention in bread while cooking reduces vitamin A retention in corn-based foods

Vitamin A stability in fats and oils

Vegetable oil has been proposed as a vehicle for vitamin A delivery by Atwood and others Rosa et al (1991) found that vitamin A fortified soybean oil stored at 23°C for 6 and 9 months retained nearly 100% vitamin A In addition, they found vitamin A retention in fortified oil was high even after cooking Atwood et al (1995) compared stability of vitamin A added to CSB and vegetable oil used in the P L 480 Food for Peace Program, employing transportation and storage conditions of CARE-India's program in 1993 CSB and vegetable oil were both commercially produced Vegetable oil was then fortified with vitamin A prior to shipment while CSB was not modified Upon arrival in different Indian ports, a 10-fold difference in vitamin A content was reported between different batches of CSB It was estimated that there was a 55-65% retention of vitamin A content in CSB between arrival and 20-week transport and storage in India compared to a 70-100% retention in vitamin A content of fortified vegetable oil These results suggested to the authors that vegetable oil may be a more effective vehicle for vitamin A delivery than CSB

Uniformity of added vitamin A

The vitamin A content of CSB produced and delivered to India in 1993 appeared highly variable (*18*) suggesting that CSB producers may not be in compliance with current USDA CSB product specifications for vitamin A addition The authors suggested that further study was warranted to determine vitamin A levels of CSB so that actual vitamin A losses that occur during shipping and storage could be more accurately determined

Summary of Vitamin A Stability Studies

Researcher	Product	Conditions	Retention (%)
Anderson & Pfeifer (1970)	flour	6 mo / 26°C	70
		6 mo / 37°C	50
		3 mo / 45°C	50
Anderson et al (1976)	breakfast cereal	6 mo / RT	100
		3 mo / 40°C	87
Cort et al (1976)	flour	6 mo / RT	97
		12 wk / 45°C	71
	cornmeal	6 mo / RT	90
		12 wk / 45°C	67
Emodi & Scialpi (1980)	bread baking		90-93
Lorenz & Jansen (1980)	corn/soy blend	extrusion (171°C)	89
Parrish et al (1980a)	bread baking		100
	corn bread baking		91
	corn mush	water addition	94
	spaghetti	varying	80-90
	corn puff	extrusion / 175°C	29
Parrish et al (1980b)	flour	6 mo / RT	100
		6 mo / 21-32°C	89
		6 mo / 40°C	50
	cornmeal	6 mo / 4°C	85
		6 mo / 21-32°C	80
		6 mo / 40°C	50
	corn flour	6 mo / 4°C	85
		6 mo / 21-32°C	80
		6 mo / 40°C	50
Rubin et al (1977)	flour	6 mo / RT	100
	breadbaking		83
	cornmeal	6 mo / RT	98
		cooking (5 min)	87
	corn grits	6 mo / RT	81
		cooking (30 min)	66-75

Vitamin C

Ascorbic acid is the most unstable of the known vitamins and is easily destroyed during cooking Due to its high water solubility, leaching of vitamin C from foods may also greatly reduce vitamin C levels Other factors that contribute to vitamin C degradation include temperature, pH, oxygen, salt and sugar concentration, enzyme and metal catalysts

In a USDA study (*19*) to help determine whether ascorbic acid should be added to wheat flour and infant cereals, lab prepared products of different composition and moisture content were fortified with coated and uncoated ascorbic acid at levels of 400 to 800 ppm These were stored at different temperatures for periods up to 7 months to determine vitamin C retention The kinetics of the vitamin loss followed first-order reactions, so results were expressed as the k constant, the higher the constant, the greater the loss Results on CSM, a predecessor to CSB, are shown below Storage temperature was the biggest factor in determining vitamin C retention

		Destruction rate k x 1000 CSM moisture content (%)		
Ascorbic Acid	Storage Temp (°C)	11 8%	10 4%	8 0%
Non-coated	45	612	205	13
	37	224	58	6
	26	21	9	2
Coated	45	303	70	4
	37	103	17	2
	26	14	4	1

Vitamin C activity in ready-to-eat cereals was investigated by (*20*) Overall losses in vitamin C activity during production of ready-to-eat cereals was estimated at 37% Stability of ascorbic acid in fortified cereal stored at room temperature was also determined over a 12-month period Ascorbic acid was reportedly stable over the initial 4 months After 4 months, however, ascorbic acid retention decreased dramatically Ascorbic acid retention after a 12 month period was 60% Short time/high temperature storage studies also indicated severe ascorbic acid losses (*21*) also investigated vitamin C retention in ready-to-eat cereals Cereal stored for 3 months at 40°C (104°F) or 6 months at 22°C (72°F) retained 93% and 94% ascorbic acid, respectively Interestingly, they found ascorbic acid addition increased vitamin A stability

The retention of ascorbic acid has also been investigated in breadmaking For example, having employed ascorbic acid encapsulated in hydrogenated soybean oil, Hung et al (*22*) reported bread retained 58% ascorbic acid immediately after baking but retained only 20% ascorbic acid after 5 days storage at 23°C Park et al (*23*) compared retention of three forms of ascorbic acid including ascorbic acid encapsulated in soybean oil, L-ascorbate 2-polyphosphate and unmodified ascorbic acid Ascorbic acid retention in three-day old bread stored at room temperature was 35%, 30% and 10%, respectively Moreover, they found ascorbic acid encapsulated in soybean oil had the highest ascorbic acid levels after baking and after storage for seven days Employing ascorbic acid encapsulated in soybean oil, Park et al (*24*) reported 99% ascorbic acid retention in bread dough before baking Immediately after baking ascorbic acid retention was 77% while storage for 7 days at 25°C resulted in less than 20% ascorbic acid retention Wang et al (*25*) investigated L-ascorbic acid and its phosphorylated derivatives in bread Breads enriched with ferrous iron and fortified with either ascorbic acid or L-ascorbate 2-polyphosphate retained 5% and 40% ascorbic acid, respectively, after 6 day storage at 25°C Thus L-ascorbate 2-polyphopsphate appears to be a more stable form of vitamin C

Park et al (*26*) investigated the fortification of bread with two fibers plus three antioxidants Ascorbic acid retention in proofed dough immediately before baking was 98% for dough with or without fiber Retention of ascorbic acid after baking was 59% in bread containing fiber and 87% in bread containing no added fiber

Seven day storage of bread resulted in retention of 3% ascorbic acid in the fiber containing bread and 14% in bread containing no added fiber The increased losses of vitamin C in the bread containing fiber was attributed to its higher moisture content (45%) compared to bread with no added fiber (37%) In another study, Dennison (27) investigated the effect of transition metals on the storage stability of ascorbic acid in a model food system They found that iron, copper and zinc had little effect on ascorbic acid oxidation in foods possessing water activity (a_w) between 0 10 and 0 40 In foods with a_w of 0 65, a 2-4 fold increase in rate of ascorbic acid destruction was observed Decrease in ascorbic acid was believed to be the result of increased mobility of the metal ions due to increased moisture content

In summary, studies indicate vitamin C retention in cereal-based products appear to be dependent on time, temperature and product moisture content Increased storage time and moisture content appear to dramatically decrease ascorbic acid retention Baking may also decrease ascorbic acid retention, however, encapsulation in soybean oil appears to reduce losses Though little work has been done on the effect of leaching on ascorbic acid in cereal-based products, leaching has been found to significantly reduce ascorbic acid in other foods when prepared in large volumes of water Thus, food preparation may have a large impact on ascorbic acid levels in the final consumed product

Natick Study

A storage study of CSB, WSB and soy fortified cornmeal (SFCM) with normal and increased levels of iron was conducted by the U S Army RD&E Center at Natick MA during FY92 for the USAID[1] The test involved storing bags of product at 80° and 100° F at ambient humidity and 90% relative humidity The high humidity conditions proved extreme for the bags, which ruptured after seven months of storage Samples were analyzed for vitamin C, vitamin A, iron and moisture at 2, 7, and 10 months of storage at 80° F and after 3 months at 100° F

Because of the limited number of samples tested and not having an initial analysis prior to storage, it was not possible to get a good estimate of vitamin retention from the results this study, whose primary objective was to determine flavor acceptability of adding more iron Levels of vitamin C in CSB were virtually the same at both storage temperatures indicating no loss Lower values of vitamin C were found in the WSB after 7 and 10 months at 80° F (37 and 34 mg/100g respectively) than in the WSB held 3 months at 100° F (46 mg/100g), indicating the possibility of a vitamin C loss in this commodity

The vitamin A results in the CSB were variable with storage time, allowing no good conclusion to be drawn on its stability The vitamin A in the WSB and SFCM did appear to be lower after 10 months at 80° and after 3 months at 100° F

OMNI Report

In 1994 USAID commissioned OMNI to prepare a Technical Review Paper on Micronutrient Fortification and Enrichment of P L 480 Title II Commodities[2] This comprehensive analysis reported on past studies of micronutrient levels found in field samples of CSB and WSB

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

1 USAID Program No BP 612786 H9900

2 Contract No HRN-5122-C-00-3025-00 Project No 936-5122

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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 l00g in the blended food commodities, and that the level of added iron from reduced iron be increased from 2 9 to 4 4mg/l00g to 8 8mg/l00g 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

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 samples

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) 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 indicating again that in these bags the mineral premix was adequately blended but the vitamin premix was not

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 a 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/l00g 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

On the issue of quality assurance of fortification, the report noted that 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

SUSTAIN Vitamin C Pilot Study

A vitamin C pilot study was designed to produce, provide and evaluate blended foods with increased levels of vitamin C fortification The results of this study (*28*) related to uniformity and stability of added vitamin C are included in this MAP report

Recommendations from Past Reports

A number of the past studies and reports on fortified food aid commodities have made recommendations which are summarized as follows

OMNI Report

1 ***Establish a quality control program for ensuring micronutrient content of P L 480 Title 11 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

2 ***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 could assist with developing uniform International Standards for micronutrients in food aid commodities

3 ***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

4 ***The OMNI report recommenced the following changes be made in the fortification of CSB and WSB***

- ***Reduce vitamin B-12 levels** by approximately two-thirds or 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/l00g would satisfy the requirements for one to three year old children and pregnant women* The level of vitamin B-12 was reduced from 4 0 to 1 3 mcg/100g effective January 1998

- ***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* No change has been made in riboflavin levels

- ***Increase the zinc levels** ten-fold 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* Zinc levels were changed from 0 9 to 4 0 mg/100g effective January 1998

- ***Change the type of zinc compound** being used Zinc sulfate monohydrate should be considered as an alternative to zinc sulfate heptahydrate since it is more stable and less expensive* The form of zinc was changed to the monohydrate form effective January 1998

- ***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* Vitamin C levels have been kept at 40 mg/100 on the recommendations of the Committee on International Nutrition - Vitamin C in Food Aid Commodities of the Institute of Medicine

5 ***Enrich wheat flour with iron, niacin, thiamin, and riboflavin***

Wheat flour is currently enriched with calcium and vitamin A It is recommended that wheat flour used in PL 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 Wheat flour provided under PL480 Title II programs has always been enriched with these micronutrients in conformance with US flour enrichment standards Wheat flour provided under Title I, however, is normally not enriched

6 ***Use ferrous fumarate instead of hydrogen reduced iron (in fortified processed foods)***

It is recommended that 5 mg of iron from ferrous fumarate be used per l00g 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

7 ***Increase ferrous fumarate (iron levels) by 50 percent***

If stability, Odor and taste tests are positive, increasing the iron supplied by ferrous fumarate from 15 mg to 22 5 mg/l00g of blended food supplements to provide 97 and 58 percent of the RDA for one to three year old children and pregnant women, respectively

8 ***Reduce the amount of tricalcium phosphate (TCP)***

The amount of TCP can be reduced by 25% 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

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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)

9 ***Do not enrich or fortify whole grains and milled rice***

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

10 ***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

11 ***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

12 ***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 11 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

13 ***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

14 ***Target delivery of commodities according to nutritional needs***

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

<u>NAS Vitamin C Fortification of Food Aid Commodities Report</u>

1 ***The level of vitamin C fortification of blended food aid commodities should NOT be increased to 90 mg/100g, but should be maintained at the current level of 40 mg/l00g***

Based on the reported incidence of scurvy and the quantity of U S-supplied blended food commodities going to regions where scurvy has been reported increasing vitamin C fortification of all CSB and WSB is not cost-effective

2 ***Strengthen health surveillance systems in refugee camps to monitor population risks of vitamin C deficiency and scurvy and to initiate a timely response***

Risk factors for vitamin C deficiency and scurvy should be monitored at the community and/or camp level Some risk factors that have been identified as potentially useful for such monitoring include populations totally dependent on food aid (e g displaced and famine-affected populations) duration of stay in a refugee camp, seasonality dry season and inability to cultivate, market failure, limited local supplies of fresh produce or lack of resources to trade for other food sources poor acceptance of donated foods especially *the blended, fortified foods, resulting from cultural preferences, and difficult access by relief organizations because of war or remoteness At the individual level, risk factors include age and physiological status (young children pregnant and lactating women and the elderly have been found more susceptible)*

3 ***Target identified populations at risk for scurvy with appropriate vitamin C interventions***

There are several possible strategies to achieve increased vitamin C supplementation (1) increased access to local foods and markets, (2) local fortification of commodities in the country or region where the emergency is occurring, as is currently practiced in some regions and (3) use of vitamin C tablets if scurvy is already present Alternatively, an increased total daily ration of conventionally fortified, blended food would be appropriate to an emergency feeding situation and would increase the intake of other important nutrients such as energy, protein, and iron, as well as vitamin C Another possibility might be for USAID's Bureau of Humanitarian Response to investigate the logistics of managing two supplies of CSB and/or WSB, the conventionally fortified blends and a small proportion of highly fortified blends that would be targeted as part of the general ration only to situations where the risk of vitamin C deficiency is high and continues for several months

4 ***Improve the uniformity of blended food aid commodities by implementing specific product and process procedures***

Delivery of vitamin and mineral fortification via food aid commodities to target populations depends on the manufacturing facilities' ability to comply with formulation and finished product specifications To improve the uniformity of blended food, the following remedial initiatives are recommended

- *Formulation document - a formal reporting of the formulation and ingredients used to generate a particular product or blend*
- *Product specifications - instituting procedures for analytical quality control to monitor compliance with fortification levels defined by product specification Inability of manufacturer to comply can result in loss of contract*
- *Methods and sampling procedures - listing of all statistical process control procedures, analytical procedures, test methods, and appropriate sampling protocol*
- *Operating guide - a formal document that provides a blueprint for operating a process It includes a process description for each step a review of normal operating conditions control actions (the set of steps necessary to maintain a quality operation), and a discussion of the impact of each process step on product quality*
- *Control plan - a master document that keeps track of a plant's record keeping It lists the specification or test to be performed the source of the authority for the test who is responsible for conducting the test the test frequency where the test is recorded what action to take and where to file or who must receive the report*
- *HACCP (Hazards Analysis Critical Control Points) plan - a preventive system to identify key areas of process control to avoid food safety risks Measurements of improvement include analytical sampling and analysis of key fortification nutrients regular audits of plant performance maintenance of calibration records for all metering equipment, and maintenance of usage records for all vitamin and mineral premixes*

The committee identified several areas in which additional research would be most helpful in alleviating potential vitamin C deficiencies and evaluating the appropriateness of any overall vitamin C fortification of U S commodities

1 ***Research the epidemiology of vitamin C deficiencies*** *Ascertain the incidence of scurvy in displaced populations and analyze this according to the amount of blended, fortified foods received The incidence of scurvy among those receiving blended foods at currently prescribed levels will permit assessment of the need to increase fortification or seek alternative approaches Develop and validate predictors of populations at risk of vitamin C deficiency among refugees so as to institute local fortification*

2 ***Research and develop means to increase consumption of local foods rich in vitamin C*** *This may also he achieved by purchasing these foods for refugees but it may be done more cost-effectively by decreasing barriers to barter and trade in refugee camps*

3 ***Research and evaluate appropriate ration sizes of blended foods*** *More information is needed on the amounts of blended foods distributed to those at risk for scurvy in displaced populations Currently, no good information is available on actual quantities distributed This may also indicate that much higher levels of fortification than are currently being considered would be necessary for those at most risk because they could be receiving smaller rations*

4 ***Research and evaluate methods for campsite vitamin C fortification*** *This would be the most cost-effective approach to fortification because the need is rare and the cost of vitamin C is relatively high*

5 ***Research alternative forms of vitamin C available for fortification*** *The limited data available on cooking losses when using the current ethyl cellulose-coated product indicate a need to develop other vitamin C products that are more stable to heating in dilute solutions*

WFP Requests on Blended Foods

Pieter Dijkhuizen, Senior Programme Advisor, Public Health & Nutrition Technical Support Service of the World Food Programme, made the following suggestions to Ms Betsy Faga, President of the Protein Grain Products Association in 1997, and similar requests to USAID subsequently

1 **The tricalcium phosphate used as a source of calcium in CSB and WSB is relatively expensive and should be replaced with calcium carbonate**

2 **There is no justification for increasing the level of vitamin C in blended foods**

3 **More information, including product composition, should be provided on bags of CSB and WSB to better meet the labeling requirements of US food laws and the Codex Alimentarius**

The Beaton Report on fortification of foods for refugee feeding

Dr George Beaton prepared an extensive report for the Canadian International Development Agency (CIDA) on the fortification of foods for refugee feeding This included advising on the composition of blended foods, which Canada does not prepare or ship Dr Beaton believed a supplemental, heavily fortified, cereal-based blended food (such as CSB and WSB) was an effective way to deliver deficient nutrients to refugee populations The following recommendations were extracted from his report but they were not intended specifically for the U S PL480 program Many of his recommendations relate to fortification of locally produced foods, and are not included here

1 ***Food aid vegetable oil should contain adequate levels of alpha-tocopherol (vitamin E)***

Oil should contain at least 0 6 mg alpha-tocopherol per gram of polyunsaturated fatty acids This is naturally present in the case of the canola oil supplied by CIDA, but some oils, like that from soy and corn may have to have vitamin E added It might be prudent to add tocopherol as an antioxidant when adding vitamin A

2 ***NaFeEDTA should be used as the iron source for fortification***

Present information indicates that this is likely to be the most efficacious source of iron will have high stability and low reactivity with other food components and is safe

3 ***More information is needed on nutrient stability during food preparation***

Existing information suggests that currently available technology can permit fortification with quite reasonable storage losses over a 6-12 month period Little if anything is known about the likely cooking methods and associated nutrient losses in refugee situations (it is noted that food preparation is likely to differ across the many cultural groups involved) It is recommended that more information be obtained about normal food preparation procedures and that there then be laboratory and field studies to ascertain an expected cooking loss for the more labile nutrients

__Report of USAID Technical Review of Vitamin C and Iron in Title II Commodities__

The following recommendations were made as a result of an expert panel meeting held July 24-25, 1990 The panelists for this review were science and technology specialists in nutrition, food and fortification technologies related to vitamin C, iron and Title II products They represented industry, academia and government

1 ***Increase the iron level of all blended food*** *supplements from the current level of l5 mg/l00g to 30 mg/l00g Continue to use ferrous fumarate as the iron source*

2 ***Increase the iron level of all protein-fortified and other processed foods*** *from the current level of l3 mg to 20 mg/lb (2 9 mg to 4 4 mg/l00g) to 40 mg/lb (8 8mg/l00g) Continue to use hydrogen reduced iron as the iron source*

3 ***Confirm the effectiveness of using iron EDTA as the iron source*** *for blended food supplements, protein-fortified and other processed foods This requires a six-month evaluation of color, flavor, and odor in stored commodities and preparation of gruels and breads Obtain iron absorption data on both ferrous fumarate fortified corn soy blend using two or more levels of ascorbic acid, and iron EDTA fortified corn soy blend*

4 ***Obtain Codex Alimentarius status for iron EDTA***

5 ***Maintain the current level of vitamin C*** *in all blended food supplements Continue to use coated ascorbic acid (97 5 percent with ethylcellulose) as the source Determine the vitamin C content of blended food supplements currently in the field by shipping samples from representative sites to the U S for analysis Continue to omit use of vitamin C in all protein-fortified and other processed foods because of severe stability problems in these relatively high moisture products*

6 ***Determine the processors capability to lower moisture content levels in blended food*** *supplements, protein-fortified foods and other processed foods to increase stability of vitamin C*

7 ***Explore the feasibility of using a new fat encapsulated source of vitamin C,*** *which in other products has been shown to be resistant to moisture Obtain vitamin C stability data on major blended food supplements during storage, cooking, and point of consumption comparing the current vitamin C source ($13 40/kg) and the encapsulated source ($24 41/kg)*

8 ***Consider alternate vitamin C delivery systems*** *to bypass or minimize vitamin C stability problems Options include vitamin C tablets for home use or portion-pack vitamin C to be added to meals or drinking water prepared in mass feeding/distribution locations such as refugee camps*

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APPENDIX B:
Scope of Work

PROGRAM DESCRIPTION

The Recipient's proposal entitled "Micronutrient Assessment Project (MAP), A Program to Assess the Stability and Availability of Micronutrient Fortificants in P L 480 Title II Commodities" and dated June 28, 1995, as modified by its August 29, 1995 Submission, is incorporated by Reference The Program Description is attached as the following Appendix

PROGRAM DESCRIPTION

I PROJECT GOAL AND OBJECTIVES

A Project Goal/Purpose

In keeping with the health and nutritional goals of USAID and the recommendations of the 1992 International Conference on Nutrition, the overall goal of the project is to improve the nutritional status of the most vulnerable elements of the world's population The specific purpose of the project is to assist the edge of the stability and availability of micronutrient fortificants in food aid commodities and by making recommendations designed to improve the long-term impact of that program on the target populations

B Project Objectives

To work toward the achievement of the project purpose, all activities developed by the project will be designed to contribute to the following project objectives

- to contribute to an increased understanding of the stability and loss of the micronutrients added to food aid commodities,
- to assess the stability of selected micronutrients added to specific Title II commodities from the point at which the micronutrients are initially added to the commodities up to the point of consumption in the field,
- to identify specific conditions that result in the loss or deterioration of micronutrient fortifications,
- to identify particular problem areas in the handling and storage of fortified food aid commodities that are detrimental to the stability of added micronutrients,
- to make recommendations for improving the stability and nutritional availability of specific fortificants,

C SUSTAIN Experience and Capabilities

The manufacture and distribution of food aid commodities involves many participants – USAID, private voluntary agencies (PVOs and CDs), the United Nations World Food Program (WFP), private industry and non-governmental organizations (NGOs) SUSTAIN has a 15-year record of successful collaboration with these groups in organizing and managing technical assistance and training programs

Working closely with a wide variety of U S private sector organizations and public agencies, SUSTAIN has implemented the transfer of technical knowledge and skills to food businesses, health and nutrition institutions, food and agriculture organizations, cooperatives, PVOS, and research institutions in developing countries in Africa, the Near East, Latin America, Asia, and the former Soviet Union

SUSTAIN promotes collaboration among USAID, U S private and scientific sectors, and developing country businesses for the purpose of improving the quality, safety, and availability of food resources in the world's developing areas Technical assistance, training, and needs assessments are provided by executives and technical specialists from the U S food industry, academia, and professional associations all of whom serve on a voluntary basis

The SUSTAIN program, which was formed in the late 1970s with support provided by USAID s Office of Nutrition, draws upon the leadership and technical expertise of a Steering Committee comprised of leading food industry executives and specialists These Steering Committee members and other volunteers contribute significant time and expertise to program development and strategic planning as well as to the actual implementation of advisory services and workshops for food industries in developing countries The volunteers work individually with SUSTAIN staff on specific projects and participate in advisory meetings with representatives of NGOs, health and nutrition institutions, the private sector and host-country governments

Over the years of its operations, SUSTAIN has developed a strong, dependable network of highly-qualified experts who provide a rapid turnaround to requests for advice and technical assistance SUSTAIN volunteer experts are available in all areas of food science and nutrition, including food product fortification, food processing, quality assurance/control, laboratory technologies, and packaging To ensure a continually high level of professional standards, the volunteers are enlisted through a process of peer recruitment and review carried out through standing network of SUSTAIN executives and experts As a result of this "in-house quality control,' SUSTAIN volunteers have continually demonstrated their effectiveness and have been well received by both the USAID missions and recipient country organizations The volunteers' contributions to food safety, nutrition, processing efficiencies, and packing have been widely acclaimed and appreciated This network of experts is representative of the unique resources that SUSTAIN brings to the implementation of the proposed project

II DESCRIPTION OF THE PROJECT

A Problems to be Addressed

The need for Nutrition Enhancement – Micronutrients (essential vitamins and minerals) have a profound effect on child survival, women's health, educational attainment, adult productivity, and overall resistance to illness

The 1992 International Conference on Nutrition, the United States Congress, and other interested agencies and organizations have urged the use of food fortification to enhance nutrition in the world's developing areas Since 1966, many processed P L 480 food aid commodities have been fortified or enriched with micronutrients may lack stability and deteriorate in food commodities during transport, distribution, and storage This project addresses the problems associated with the loss of beneficial micronutrients in food aid commodities by gathering the baseline data and information required to deal with these problems

Micronutrient deficiencies form the basis for a wide variety of health and economic problems throughout the developing world Deficiencies of such essential nutrients as Vitamin A, iodine, and iron are especially detrimental because of their serious health consequences Lack of iodine can cause goiter, an enlargement to the thyroid gland, diets insufficient in iron can lead to anemia, which in turn restricts and individual's utilization of energy and limits his/her productive activities Vitamin A deficiencies can lead to increased severity of diarrhea, respiratory and other infections

There are a number of reasons why an estimated 2 billion people in the world's developing areas fail to consume or lack the essential levels of vitamins and minerals

- food products that are rich in micronutrients may be only seasonal or too expensive,
- the way in which foods are prepared may reduce the availability of vitamins and minerals,
- natural sources of iodine in the soil may be depleted,
- certain intestinal parasites may intensify nutrient deficiencies
- traditional norms and customs may restrict the cultivation and/or consumption of certain micronutrient-rich foods by some segments of the population

Fortifying commonly eaten foods with the missing micronutrients is one mechanism for making essential vitamins and minerals available to the populations of these areas

In the mid-1960s, to prevent micronutrient deficiencies among P L 480 recipients, USAID and USDA initiated a program to fortify or enrich processed and partially-processed food aid commodities During fiscal year 1994, the U S government provided more than 5 million metric tons of food aid commodities (valued a t $174 billion) to 79 developing and re-industrializing countries through its P L 480 programs USAID and USDA work in partnership with recipient governments, PVOs, the WFP and international relief agencies in the provision and distribution of these commodities

Problems of Micronutrient Deterioration – Over time and depending on shipping/storage conditions, some micronutrients break down to unusable forms or can cause the commodities to become rancid Other micronutrients, such as certain iron compounds, can react with the nutrients to cause off-flavors and odors Iodine fortification is accomplished with both iodide and iodate compounds, such as potassium iodide, which is more soluble and needed in smaller quantities However, it is unstable when exposed to high temperatures moisture, sunlight, excessive aeration, or the presence of salt impurities Potassium iodate is a more stable additive, but with the increased stability come increased costs As noted in Section I, A, other micronutrients are broken down by such simple things as light, heat and air

Because food aid represents an increasingly limited resource that must be used to maximum effect, it is important to assess the stability and availability of micronutrient fortificants in food aid commodities as they move though the rigors of long-distance transportation, storage, and distribution The 1993 total expenditure on fortification and enrichment ingredients was estimated at $15 064 million To assist USAID in assessing the role that P L 480 commodities can play in reducing or preventing micronutrient deficiencies, the proposed SUSTAIN project, to be implemented over a two-year period in close collaboration with the Bureau of Humanitarian Response and technical expertise from the Office of Health and Nutrition/Nutrition & Maternal Health in the global Bureau, will assess the stability and availability of micronutrient fortificants in selected food aid commodities as they move from the point of manufacture to the point of consumption by end users This information will assist USAID to evaluate the cost-effectiveness of various interventions designed to address micronutrient deficiencies

B Project Inputs

The major inputs of the project include a project manager with both academic training and professional experience in food science and nutrition, and the structured participation of a significant number of volunteer experts It is estimated that some 8 to 12 person/months of volunteer consulting services will be provided by the advisory panel, cooperating food technicians and volunteers from collaborating NGOs/PVOs It is also anticipated that some professional consulting services will be utilized and that additional expertise and technical assistance will also be drawn form USAID/PHN/HN/NMH

It is expected that the program manager will have, at a minimum, a Master's degree in food science and/or nutrition and appropriate professional experience and knowledge in micronutrients It is also expected that the program manager will have some experience in a developing country context and a familiarity with supplemental feeding programs SUSTAIN management will confer with BHR on the final selection of a candidate to fill the management position In consultation with SUSTAIN management and the steering Committee the program manager will set up the expert panel and develop an annual work plan

The design of the program components, including a determination of the countries to be targeted in each of USAID's geographic regions, will be developed in consultation with the advisory panel and the appropriate officers of USAID/BHR and USAID/G/PHN/HN/NMH

C Project Implementation and Reports

The implementation of the project will include

- A survey of the literature on recent and current research relating to the stability of micronutrient fortificants in commodities distributed under the P L 480 Title II program [2]

- the development of a sampling plan and methodology for gathering samples in the field (samples will be collected at (1) the point of commodity nutrient blending in the U S , (2) the port of embarkation and disembarkation, (3) during the removal from the overseas storage facilities, (3) at the time of commodity distribution to beneficiaries, and (4) after being prepared for consumption in refugee camps or homes), [3]

- to the extent necessary, and depending on the availability of funds and the final design of the sampling protocol, laboratory tests simulating the temperature, humidity, light and other physical conditions may also be conducted,

- a plan to ensure the proper handling and packing of the samples for shipment to a qualified U S laboratory that conforms to appropriate standards and norms,

- the review of all testing results and related recommendations by the project advisory panel and any outside experts who the panel may decide to involve

- the forwarding of all testing results to the appropriate officers of USAID/BHR through an informal system of periodic letters and reporting data submitted when new and relevant information becomes available,

- the submission of progress reports, at six-month intervals, which will provide information on test results, technical briefing notes, an up-date on activities implemented and any specific issues or problem areas that may arise, as well as a summary of financial expenditures, [4]

- periodic technical advice on significant issues in food science and nutrition will be provided to USAID/BHR by the MAP program manager, subject to their availability and the priorities of this project Such requests would be submitted in writing by BHR to SUSTAIN's Executive Director for concurrence

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[2] Abstracts of directly revelant documents will be provided to USAID/BHR

[3] It is anticipated that field assessments will be made in four to eight countries, depending on the availability of funds The selection of the countries, the specific micronutrients, and the specific Title II commodities to be sampled and analyzed will be determined in collaboration with USAID/BHR and USAID/G/PHN/HN/NMH at the time the sampling protocol is determined Input will also be gathered from collaborating PVOs and the WFP It is anticipated that the sampling will cover P L 480 Title II fortified commodities distributed through U S PVOs and the WFP that reach the end users in the same form they were provided by the United States government To the extent that the transportation, storage and distribution systems of the WFP differ substantially from those of U S PVOs, there may be a need to increase the sample size (and consequently project funding) to maintain the integrity of the study

[4] the intent of the reporting process is to provide relevant information to USAID Should it become apparent that a format other than the six-month reports is more appropriate, the process can be modified by the mutual agreement of USAID/BHR and SUSTAIN The end of project report (in place of the last six month report) will include a description of the sampling protocol, a review of all project activities, test results and recommendations

Implementation Plan – The specific initial steps in the implementation of project activities include the following

- Selection of the MAP Manager – Within the first 30 days of implementation, SUSTAIN management will provide USAID/BHR with an opportunity to review and comment on a short-list of qualified candidates for the position of project manager

- Development of the Overall Implementation Plan– Within the first 60 days of project activity, project management will provide USAID/BHR with the general implementation plan covering the full duration of the project

- Organization of the Advisory Panel – During the first 90 days of the project, management will complete the recruitment of a panel of experts drawn from the food industry sector and academia to advise the project manager on program activities and commodity testing and to make recommendations on issues of food commodity fortification

To gain the most benefit possible from the project, it is important that the separate but collaborative roles of SUSTAIN and USAID/BHR be clearly delineated and understood The primary role of SUSTAIN in the implementation of the MAP is to conduct a scientific study, as described in this proposal, and to provide USAID with its findings and recommendations The extent of involvement of other interested parties, such as the micronutrient manufacturers, commodity manufacturers, PVOs, the WFP, USDA and other Federal Agencies, as well as other units of USAID, will be decided and organized by USAID/BHR BHR's role is to review the information and findings of the MAP and make whatever policy decisions it determines to be necessary

The communication of MAP findings and recommendations to interested third parties will be coordinated and managed by BHR To the extent necessary, MAP management will be made available to brief members of official USAID committees, such as the Joint Committee on Nutritional Specifications of Food Aid Commodities and the Food Aid Consultative Group authorized under section 205 of the Agricultural Trade Development and Assistance Act of 1954

The initial project report, to be submitted at the end of the first six months of implementation, will include a description of the sampling plan and methodology as well as the results of the initial sample analyses The formal project report, to be submitted at the conclusion of the project, will describe the distribution and storage process and the condition of the facilities utilized It will also include information on all project activities, including the results of all laboratory analyses and the recommendations of project management and the advisory panel Intermittent reports, in the form of letters and analytical documents, will be provided to USAID on a periodic basis as relevant information becomes available

D Project Management and Organization

SUSTAIN management, operating from its Washington, DC headquarters, will have overall responsibility for the administration and implementation of the project Day-to-day operational responsibility will be in the hands of the professional MAP project manager, who will serve as the primary liaison with USAID missions and organize the work of the advisory panel and the paid and volunteer consultants The project manager position is budgeted for a period of 20 months (see Section IV, A, Budget Narrative) A half-time administrative support person is also included in the budget Although the SUSTAIN Executive Director will be regularly consulted by the MAP manager and will be involved in planning, liaison with the SUSTAIN Advisory Committee, and reviewing project reports, only a small percentage of the Executive Director's time is included in the project budget

SUSTAIN's organizational background, management staff, external technical resources and operational experience makes it fully capable of administering and overseeing this type of project In addition to its in-house experience and administrative capacities, to address specific organizational, business and technical issues, SUSTAIN is able to draw on the experience of some of America's largest private sector food companies and academic institutions

Major Assumptions

Because certain conditions are required for the successful implementation of this type of project, in developing this proposal SUSTAIN management assumes there will be a sufficient level of cooperation from host-country governments, USAID missions, the WFP, and the NGOs/PVOs, and participating in food commodity distribution In summary, the following major assumptions are basic to the full achievement of the project's purpose and objectives

- that host-country governments, NGOs/PVOs, and the WFP will cooperate with and assist the program manager by providing information on how food aid shipments are shipped, received, stored, distributed and utilized in their programs, will provide access and logistical support to get to project sites and beneficiaries for the procurement of samples, and will assist with logistics to facilitate sampling

- that USAID missions will grant permission to conduct project sampling and analysis activities and that USAID/BHR will facilitate necessary communications with the missions

- that the countries selected for sampling will remain stable for the period of time required to obtain the samples and relevant information on storage, distribution and utilization

- that USAID will help facilitate MAP access to relevant databases, literature, and the management of companies participating in Title II micronutrient programs,

- that the pre-mix manufacturers participating in the Title II program will provide information on any relevant studies they have undertaken, underway, or identified as useful,

- the specific Title II commodities to be sampled and analyzed will be determined in collaboration with USAID/BHR and USAID/G/PHN/HN/NMH at the time the sampling protocol is determined Input will also be gathered from collaborating PVOs and the WFP It is anticipated that the sampling will cover P L 480 Title II fortified commodities distributed through U S PVOs and the WFP that reach the end users in the same form they were provided by the United States government To the extent that the transportation, storage and distribution systems of the WFP differ substantially from those of U S PVOs, there may be a need to increase the sample size (and consequently project funding) to maintain the integrity of the study

APPENDIX C
Description of Analytical Methods

Vitamin A was run by an AOAC High Performance Liquid chromatograph (HPLC) procedure where the sample was saponified with an overnight shake-out and the unsaponified material was extracted with hexane The hexane extract was injected into a normal phase HPLC system with a silica column and quantified by comparison to the standard using detection at 313nm The detection limit is 20 IU/100g The NIST dry infant cereal reference standard was run with each set The results were not used and the set repeated if the standard fell outside of a 1719-2173 IU/100g range, providing for a 9 2% analytical error

Vitamin C was tested by the fluorescent method, Association of Official Analytical Chemists (AOAC) 15th Ed 967 22 This procedure is applicable to foods and feeds It measures both reduced vitamin C (ascorbic acid) and the oxidized form (dehydro ascorbic acid), both of which are antiscorbutic The procedure does not measure the hydrolyzed form, 2,3-diketogulonic acid, which does not have vitamin C activity The procedure involves oxidizing ascorbic acid to dehydro ascorbic acid in the presence of charcoal The oxidized form reacts with 0-phenylenediamine to produce a fluorophor whose fluorescent intensity is proportional to the concentration A blank is formed by adding dehydro ascorbic acid to boric acid to form a quinoxaline prior to the addition of the diamine solution Any remaining fluorescence is due to extraneous materials A spike was run with every set of samples The average spike recovery on a variety of matrices is 96 2% The detection limit on this procedure is 1 mg/100g A NIST (National Institute of Standards and Technology) dry infant cereal reference standard (AOAC, 1986, 1990) was run with each set If the standard fell outside of a 108–121 mg/100g range, the results were not used and the set was repeated, providing for an 11 4% analytical error

Niacin was analyzed by the American Association of Cereal Chemists approved method 86-52 Niacin Automated Determination This method is an automated version of the colorimetric procedure in which an autoclaved calcium hydroxide extraction of a cereal product is acidified and reacted with cyanogen bromide to produce a blue color proportional to the amount of niacin present The reading is adjusted for natural color by running a blank with no cyanogen bromide An AACC flour reference standard was run with each set If the standard fell outside of a 22–27 mg/100g range, the results were not used and the set was repeated providing for a 20% analytical error

The same analytical methods were used on the prepared food samples as were used on the dry samples except for moisture content, which was measured by vacuum oven

For the dry samples, moisture was tested by a standard loss of weight in oven drying The laboratory ran the NIST dry infant cereal reference standard containing a certified level of vitamin C with each sample set The whole run was repeated if the assay on the standard was outside of the acceptable range For the cooked samples, moisture was tested by a standard loss of weight during vacuum oven drying Samples high in sugars were dried at 70°C for 16 hours Samples high in volatile oils were dried at 100°C for 5 hours In all cases the samples were dried under pressure less than or equal to 100 mm Hg The limit of detection is 0 01%

Water activity (a_W) is a water energy measurement Water activity is an indication of "free" water in a sample available for microbial growth, as well as enzyme and vitamin activity "Free" refers to the water particles in a product that are not chemically or physically bound

A representative sample was placed in the Atwater instrument and the a_W or equilibrium humidity (ERH) was measured as a ratio of water vapor pressure above the sample to the water vapor of pure water at the same temperature Products with no "free" water have an a_W of 0 000, pure water has an a_W of 1 000 (Aqualab Model CX-2 Water Activity Measurement Operator's Manual)

Iron was tested by digesting the sample at 600° C , extracting the ash with acid and measuring the iron content with atomic absorption according to AOAC method 968 08 The precision on this test is 4 8% and the detection limit is 2 ppm according to laboratory A NIST 1846 SRM cereal iron standard was run each day The iron result on the NIST standard had to fall within 59 1-67 1 ppm for the results to be usable providing for a 6 3% analytical error

Appendix D 1

Key for Results in Laboratory Food Preparation Studies

Vitamin C added	The level of vitamin C added
Conventional Vitamin C	Level (40mg/100g)
High Vitamin C	Level (90mg/100g)
Sampled	1 The country in which the sample was taken 2 Which position of the bag the sample was taken from a- top of the bag b- middle of the bag c- bottom of the bag
Sample Designation	Identification code of samples
Preparation type	The type of CSB/WSB based meal prepared
Moisture in CSB/WSB Before cooking (% by wt)	Laboratory assay of the moisture content of the uncooked CSB/WSB reported as a percentage of weight
Moisture in food mixture After cooking (% by wt)	Laboratory assay of the moisture of the respected food preparation after cooking, reported as a percentage of weight of the cooked ingredients including CSB/WSB
Vitamin C in CSB/WSB Before cooking, wet basis (mg/100g)	Milligrams of Vitamin C per 100grams of uncooked CSB/WSB based on total weight including moisture
Vitamin C in CSB/WSB Before cooking, dry basis (mg/100g)	Milligrams of Vitamin C per 100 grams of uncooked CSB/WSB based on solid content (calculated by factoring out moisture content)
Vitamin C in food mixture after cooking, wet basis (mg/100g)	Milligrams of Vitamin C per 100 grams of cooked food preparation based on total weight (including moisture)
Vitamin C in food mixture after cooking, dry basis (mg/100g)	Milligrams of vitamin C per 100 grams of cooked food preparation based on solid content (calculated by factoring out moisture content)
Vitamin C retention Dry basis (%)	Measurement of the degree to which vitamin C remains in prepared food after cooling based on solid content (calculated by comparing vitamin C levels in the cooked food preparation with vitamin C levels in the uncooked CSB/WSB
Time in water before Cooking (min sec)	The length of time CSB/WSB spent in the water before being cooked
Time of cooking (min sec)	The length of time WSB/CSB was cooked

Appendix D 1

Key to Laboratory Study Table

Four different types of food preparation were prepared mainly dependent on their concentration

Beverage	8 3% CSB
Gruel	13 8% CSB or WSB
Paste	20 0% CSB or WSB
Dumpling	41 5% WSB

WSB was made in gruel, paste and dumplings CSB was made into beverage, gruel and paste The target level of vitamin C added was either conventional (40 mg/100g) or high (90 mg/100g) but the level of vitamin A added was similar in both cases but the source of vitamin A would be different

The theoretical level of the vitamin in the cooked food was calculated from the assayed level in the dry food corrected for the CSB/WSB concentration in the food Percent retentions were calculated as the average level of the vitamin during the first twenty minutes of cooking as a percentage of that theoretical level and as the final level found as a percentage of that theoretical level

Appendix D 1

Laboratory Food Preparation Studies - Temperatures and Conditions

WHEAT SOY BLEND

	Gruel		Paste	
Type/% WSB in product				
Vitamin C level added	Normal	High	Normal	High
pH		6 9	6 8	6 8
Cooking Time (min)	Temperature (degrees C) of Food during Cooking			
0		73		
5			57	78
10	82	98		
15		98	93	98
20	98	98		
30	99	89		
45			76	89
60	59	71		
75			57	51
90	47	64		
120	39	51	36	30

CORN SOY BLEND

	Beverage		Gruel		Paste	
Vitamin C level	Normal	High	Normal	High	Normal	High
pH	6 8	7 2	6 6	6 7	6 9	6 8
Cooking Time (min)	Temperature (degrees C) of Food during Cooking					
0	69	70	50	58	38	
5	98	99			67	
10	89	96	98	98		
15			95	97		
20	75	90	96	93	80	88
30	64	59	91	93		
45					83	56
60	53	38	70	55		
75					50	33
90	34	38	47	54		
120		33	35	45	32	

Conditions of Food Preparations

	Beverage	Gruel	Paste	Dumpling
Mix				
CSB or WSB (g)	125	350	500	200
water (ml)	500	1400	2000	280
hot water (ml)	750	600		
sugar (g)	125	175		(2000 ml)
salt (g)	3	3 5	5	2
TOTAL (g)	1503	2528 5	2505	482
Percent CSB/WSB in food not correcting for evaportation				
	8 3%	13 8%	20 0%	41 5%

Appendix D 1

Laboratory Food Preparation Studies - Vitamin A Results

WHEAT SOY BLEND

Type of Food	**Gruel**		**Paste**		**Dumpling**	
vitamin A level added	Normal	High	Normal	High	Normal	High
	Starting level of vitamin A (IU/100g) in food based on calculation					
	323	262	465	377	967	784
Cooking Time (min)	Assayed level of vitamin A (IU/100g) in food product					
0	330	180			790	630
5			380	340	730	670
10	280	270				
15		300	380	370	590	530
20	370	270				
25					630	540
30	370	320				
45			440	350	640	670
60	300	320				
75			450	440		
90	380	320				
120	340	320	440	360		
Retention of vitamin A						
Mean 20 min Retention (%)	101	97	82	94	73	78
Final Retention (%)	105	122	95	95	66	85

CORN SOY BLEND

	Beverage		**Gruel**		**Paste**	
	Normal	High	Normal	High	Normal	High
	Starting level of vitamin A (IU/100g) in food based on calculation					
	170	179	282	298	407	429
Cooking Time (min)	Assayed level of vitamin A (IU/100g) in food product					
0	150	50	90	60	190	140
5	150	110			200	240
10	150	110	190	250		
15			200	280	330	240
20	160	140	250	330		
30	170	130	230	350		
45					340	330
60	200	150	250	350		
75					330	320
90	170	160	210	350		
120		110	240	350	370	
Retention of vitamin A						
20 min (%)	90	67	76	96	59	48
Final (%)	100	61	85	117	81	75

Appendix D 1

Laboratory Food Preparation Studies - Vitamin C Results

WHEAT SOY BLEND

Type of Food	Gruel		Paste		Dumpling	
Vitamin C level added	Normal	High	Normal	High	Normal	High
	Starting level of vitamin C (mg/100g) in food based on calculation					
	5	13	7	18	15	38
Cooking Time (min)	Assayed level of vitamin C (mg/100g) in food product					
0	3	9			12	23
5			5	13	6	17
10	3	9				
15		9	5	11	5	13
20	3	8				
30	3	9			5	13
45			5	12	4	10
60	3	9				
75			5	11		
90	3	7				
120	3	9	4	10		
Retention of Vitamin C						
Mean 20 min Retention (%)	59	69	68	66	50	47
Final Retention (%)	59	71	54	55	26	26

CORN SOY BLEND

	Beverage		Gruel		Paste	
	Normal	High	Normal	High	Normal	High
	Starting level of vitamin C (mg/100g) in food based on calculation					
	2	8	3	13	7	19
Cooking Time (min)	Assayed level of vitamin C (mg/100g) in food product					
0	2	6	4	13	5	11
5	2	6			5	10
10	2	6	3	10		
15			3	11		
20	2	6	3	11	4	10
30	2	6	3	11		
45					4	10
60	2	6	3	11		
75					3	10
90		6	3	11		
120		6	3	11	3	
Retention of Vitamin C						
20 min (%)	96	77	94	86	63	55
Final (%)	100	77	100	77	41	53

Appendix D 1

Laboratory Food Preparation Studies - Effect of Wetting

Product	Plant Source	Addition Target	Vitamin C (mg/100g) Normal Method	Wetted 3 min	Wetted 6 min	Wetted 10 min	Wetted & Heated 6 min
WSB	B	40	39	43	37	40	30
WSB	B	90	69	66	75	64	56
CSB	A	40	19	25	18	26	17
CSB	A	90	87	89	89	88	80
CSB	C	40	41	48	47	35	29
CSB	C	40	37	27	29	30	23
CSB	E	40	49	51	32	41	50

20 ml tap water was added to 5 gram of product for wetted samples

After indicated time, extracting solution was added and analysis continued to completion

Heating was done at 80 degrees C for six minutes

Appendix D 2

KEY for Analytical Data on Commodities Collected at Recipient Sites

Vitamin C assay	Results of measures for milligrams of vitamin C per 100 grams of commodity
Niacin assay	Results of measures for milligrams of niacin per 100 grams of commodity
Moisture assay	Results of measures for milligrams of water per 100 grams of commodity
Water Activity assay	Ratio of the vapor pressure of water in equilibrium with food and the vapor pressure of pure water at the same temperature
Vitamin A	Results of measures for milligrams of Vitamin A per 100 grams of commodity
FGIS	Composite lot samples from the Federal Grant Inspection Service
Sample Number	Identification code of samples that can include lot number, sampling, date, sampling time, etc
Vitamin C added	The level of vitamin C added
Conventional Vitamin C	Level (40mg/100g)
High Vitamin C	Level (90mg/100g)
Bag Location/Sampled	1 The country in which the sample was taken 2 Which position of the bag the sample was taken from a- top of the bag b- middle of the bag c- bottom of the bag
Bag Average	Average taken from the group of 3,4 or 5 samples directly before the average
Time of cooking (min sec)	The length of time WSB/CSB was cooked

Appendix D 2

Data on Samples Collected in Bolivia

Contract	Lot	Bag Location	Vitamin A (IU/100g) FGIS	Bolivia
Wheat Flour at FHI-EL ALTO-LA PAZ				
1635	628	B	1320	1 510
1635	629	A	1450	1,420
1635	632	B	1570	1,710
1635	635	B	1820	1,720
1635	637	A	1760	1,610
1624	1408	A	1720	1,740
1624	1409	A	2180	1,980
1624	1450	A	2210	2,070
1624	1451	B	2340	2,020
1624	1453	B	2140	1,870
1624	1463	B	1900	2,050
1624	1464	B	2420	1,960
1624	1465	C	1920	2,120
1624	1467	B	1860	1,830
1635	1718	C	1630	1,670
1635	1719	A	1720	1,620
1635	1719	B	1720	1,540
1635	1722	A	1850	1,740
1635	1733	C	1730	1,750
1624	1452	B	2200	1,960
1624	1454	A	2400	2,050
1624	1455	B	2060	2 350
1624	1457	C	2270	2 060
1624	1458	A	1900	1,940
1624	1459	C	2040	2,020
1624	1460	A	1900	2,100
1624	1466	B	2230	2,150
1624	1467	B	1860	2 150
1635	637	B	1760	1,940
1635	642	A	2030	1,880
1635	642	B	2030	2,080
1635	652	A	1690	1 870
1635	652	B	1690	1,810
1635	658	C	1920	1 840
1635	1703	A	1410	1 490
1635	1704	A	1090	1 430

Appendix D 2

Data on Samples Collected in Bolivia

Contract	Lot	Bag Location	Vitamin A (IU/100g) FGIS	Bolivia
1635	1704	B	1090	1,100
1635	1710	A	1670	1,680
1635	1719	B	1720	1,540
1635	1719	C	1720	1,630
1635	1720	A	1730	1,700
1635	1722	A	1850	1,600
1635	1722	B	1850	1,600
1635	1735	A	1680	1,710
1635	1735	B	1680	1,750
1635	1736	A	1700	1,760
1635	1737	A	1700	1,660
1635	1746	B	1820	1 670
1635	1746	C	1820	1,700
1635	1752	A	1600	1,700
1635	1752	B	1600	1,740
1635	1753	B	1620	1,710
1635	1768	B	1900	1 940
1635	1768	C	1900	1,710
Bulgur at FHI-POTOSI-BOLIVIA ALMACEN				
1619	A 1			490
1619	C 1			610
1619	B 2			800
1619	A 2			360
1619	B 3			400
1619	C 3			560
1619	A 4			690
1619	B 4			420
1619	A 5			430
1619	B 5			660
1619	B 6			400
1619	C 6			610
1619	16	C	530	530
1619	15	A	520	520
1619	10	A	550	580
1619	13	B	560	870

Appendix D 2

Vitamin C content in WSB at Production and at Recipient Site in Haiti for same bags

Lots 1 through 4 have conventional level of vitamin C added
Lots 5 through 8 have high level of vitamin C added

Sample number	Time	Day	lot	VITAMIN C (mg/100g) at Production	in Haiti	Difference
4	750	8-Jul	1	44	40	-4
5	830	8-Jul	1	45	38	-7
6	915	8-Jul	1	39	43	4
7	940	8-Jul	1	50	37	-13
11	1030	8-Jul	1	32	40	8
12	1045	8-Jul	1	52	38	-14
13	1150	8-Jul	2	48	39	-9
17	1310	8-Jul	2	47	35	-12
20	1335	8-Jul	2	45	38	-7
23	1405	8-Jul	2	44	35	-9
26	1425	8-Jul	2	40	38	-2
28	1450	8-Jul	2	37	38	1
31	1515	8-Jul	2	42	35	-7
36	730	9-Jul	2	38	34	-4
38	750	9-Jul	3	38	41	3
41	855	9-Jul	3	47	41	-6
45	950	9-Jul	3	41	35	-6
49	1035	9-Jul	3	44	40	-4
50	1045	9-Jul	3	49	37	-12
53	1105	9-Jul	3	43	37	-6
55	1120	9-Jul	3	43	35	-8
59	1240	9-Jul	3	50	37	-13
61	1315	9-Jul	3	40	34	-6
67	1410	9-Jul	4	39	38	-1
75	850	10-Jul	4	39	34	-5
76	900	10-Jul	4	37	40	3
78	945	10-Jul	4	44	36	-8
80	1130	10-Jul	5	60	84	24
90	1445	10-Jul	5	87	69	-18
91	1450	10-Jul	5	76	80	4
97	1250	10-Jul	5	72	85	13
102	1330	10-Jul	5	89	76	-13
107	1405	10-Jul	5	66	92	26
110	710	11-Jul	5	88	85	-3
111	730	11-Jul	5	100	91	-9
112	805	11-Jul	5	92	82	-10
114	905	11-Jul	6	71	79	8
115	935	11-Jul	6	66	95	29
116	1010	11-Jul	6	69	100	31
119	1345	11-Jul	7	64	81	17
121	1110	11-Jul	6	74	74	0
123	1140	11-Jul	6	58	63	5
131	820	12-Jul	7	67	70	3
132	850	12-Jul	7	82	95	13

Appendix D 2

Vitamin C content in WSB at Production and at Recipient Site in Haiti for same bags

Sample number	Time	Day	lot	VITAMIN C (mg/100g) at Production	in Haiti	Difference	Percent Retention
138	1450	12-Jul	6	69	81	12	
140	1440	12-Jul	6	88	88	0	
142	910	12-Jul	7	66	63	-3	
147	945	12-Jul	7	78	78	0	
149	1030	12-Jul	8	77	82	5	
153	1110	12-Jul	8	67	63	-4	
155	1125	12-Jul	8	60	72	12	
157	1250	12-Jul	8	84	76	-8	
160	1345	12-Jul	8	83	99	16	
		Average	All			-0 18	
		Std Dev				11 47	
		Average	1-4	42 85	37 52	-5 33	87 55%
		Std Dev		4 70	2 39	5 48	
		number		27			
		Average	5-8	75 46	80 96	5 50	107 29%
		Std Dev		10 86	10 39	13 29	
		number		28			

Appendix D 2

Tanzania Dry CSB Samples

Sample Number	WATER (%)	VITAMIN A (IU/100g)	ASSAY VITAMIN C (mg/100g)	NIACIN (mg/100g)	Vitamin C level added	VITAMIN C TO NIACIN RATIO
CSB012097H1Da01	9 66	2,270	94	8 5	High	11 1
CSB012097H1Db02	9 57	2,170	95			
CSB012097H1Dc03	9 63	2,130	88			
CSB012097H1Da04	9 74	2,110	96	8 7		11 0
CSB012097H1Db05	9 71	2,020	96			
Bag average	9 66	2,140	94	8 6		
CSB012097C5Da06	9 46	890	36	5 4	Conv	6 7
CSB012097C5Db07	9 45	930	23			
CSB012097C5Dc08	9 43	650	22			
CSB012097C5Da09	9 39	1,030	28			
CSB012097C5Db10	9 33	830	34			
Bag average	9 41	866	29	5 4		
CSB012197C6Da11	9 62	970	24	5 5	Conv	4 4
CSB012197C6Db12	9 57	1,100	27			
CSB012197C6Dc13	9 57	880	33	5 5		6 0
CSB012197C6Da14	9 50	940	25			
CSB012197C6Db15	9 63	1,130	29			
CSB012197C6Dc21	9 81	1 060	28			
Bag average	9 62	1,013	28	5 5		
CSB012197H2Da16	9 53	3,870	160	14 0	High	11 4
CSB012197H2Db17	9 52	3,530	160			
CSB012197H2Dc18	9 57	3,720	160			
CSB012197H2Db19	9 55	3,730	140			
CSB012197H2Dc20	9 55	4,350	160			
Bag average	9 544	3,840	156	14 0		
CSB1a011897H	10 00	630	15	3 8	High	3 9
CSB1b011897H	10 00	580	13			
CSB1c011897H	9 74	800	21			
Bag average	9 91	670	16			
CSB2a011897H	10 20	990	29	5 3	High	5 5
CSB2b011897H	10 20	980	29			
CSB2c011897H	10 20	1,020	31			
Bag average	10 20	997	30			
CSB5a011897C	9 59	1,020	27	5 1	Conv	5 3

Appendix D.2

Tanzania Dry CSB Samples

Sample Number	WATER (%)	VITAMIN A (IU/100g)	ASSAY VITAMIN C (mg/100g)	NIACIN (mg/100g)	Vitamin C level added	VITAMIN C TO NIACIN RATIO
CSB5b011897C	9 59	1,120	16			
CSB5c011897C	9 59	1,020	26			
Bag average	9 59	1,053	23			
CSB6a011897C	9 04	460	6	3 6	Conv	1 7
CSB6b011897C	9 20	290	7			
CSB6c011897C	9 32	400	14			
Bag average	9 19	383	9			
CSBVEPE00393a901	9 65	1,530	31	17 6	Conv	1 8
CSBVEPE00393b901	9 71	1,860	30			
CSBVEPE00393c901	9 72	1,380	36			
Bag average	9 69	1,590	32			
CSBVEPE00393a915	10 50	1,700	32	22 8	Conv	1 4
CSBVEPE00393b915	10 40	1,350	22			
CSBVEPE00393c915	10 40	2,410	31			
Bag average	10 43	1,820	28			
CSBVEPE00343a929	10 10	920	31	15 2	Conv	2 0
CSBVEPE00343b929	10 10	1,530	35			
CSBVEPE00343c929	10 10	2,540	34			
Bag average	10 10	1,663	33			
CSBVEPE00393a940	9 90	850	16	4 3	Conv	3 7
CSBVEPE00393b940	9 84	1,260	21			
CSBVEPE00393c940	9 87	610	20			
Bag average	9 87	907	19			
CSBVEPE00393a966	8 96	1,590	39	25 6	Conv	1 5
CSBVEPE00393b966	9 64	1,640	31			
CSBVEPE00393c966	8 80	2,780	35			
Bag average	9 13	2,003	35			

Conventional Vitamin C Level (40mg/100g)
High Vitamin C Level (90mg/100g)

Appendix D 2

CSB samples collected in India

Contract VEPE00437 LOT No	Sampled	Location	Lot	Vitamin A IU /10g	Vitamin C mg/100g	Niacin mg/100g	Moisture %	Water Activity
A0588AA	Top	5	AA	2020	45	6 0	8 64	0 432
A0939AA	Bottom	5	AA	1870	50	6 0	8 64	0 438
A1241AA	Bottom	5	AA	1800	40	6 0	8 43	0 416
A1444AA	Top	2	AA	1860	37	5 8	8 93	0 428
A2669AA	Top	4	AA	1990	36	6 8	8 97	0 398
A0064AB	Top	6	AB	1980	39	6 7	9 05	0 421
A0078AB	Bottom	6	AB	1930	42	7 0	8 94	0 415
A0421AB	Bottom	5	AB	1800	41	6 6	9 19	0 437
A0877AB	Top	4	AB	1920	41	6 7	9 24	0 441
A0893AB	Top	4	AB	2020	37	6 8	9 28	0 411
A1023AB	Top	4	AB	1780	40	6 8	9 31	0 441
A1024AB	Bottom	1	AB	1750	39	7 0	9 11	0 437
A1032AB	Top	3	AB	1950	43	6 7	9 20	0 445
A1349AB	Top	7	AB	1970	54	6 4	9 18	0 445
A1359AB	Top	3	AB	1800	49	6 4	9 17	0 448
A1360AB	Bottom	4	AB	1800	36	7 0	9 15	0 456
A1382AB	Top	5	AB	1890	36	6 0	9 15	0 454
A2282AB	Bottom	4	AB	1530	35	5 8	8 79	0 418
A2286AB	Bottom	3	AB	1840	34	6 0	8 93	0 421
A2288AB	Bottom	4	AB	1510	36	5 7	8 85	0 416
A2290AB	Bottom	4	AB	1850	33	5 8	8 80	0 387
A2294AB	Bottom	1	AB	2090	36	6 0	8 89	0 402
A2300AB	Bottom	4	AB	1820	40	5 6	8 79	0 401
A2461AB	Top	5	AB	1870	36	5 6	8 98	0 422
A2599AB	Top	5	AB	2000	35	6 3	8 98	0 420
A2686AB	Top	4	AB	1570	35	6 4	8 75	0 391
A0145AC	Bottom	5	AC	1560	39	6 0	8 52	0 391
A0548AC	Top	5	AC	1740	47	5 8	8 67	0 390
A0I53AC	Top	5	AC	1780	32	5 9	8 90	0 414

Key to Location

1	Center 38
2	Center 40
3	Center 120
4	Warehouse
5	Warehouse
6	Center
7	Center
8	Center

		Vit A	Vit C	Niacin	Moisture	W A
AA and AB lots only	Average	1854 23	39 42	6 30	8 97	0 425
	Std Dev	143 37	5 13	0 46	0 22	0 019
	N	26	26	26	26	26 000
All samples	Average	1837 59	39 41	6 26	8 95	0 422
	Std Dev	147 57	5 24	0 45	0 23	0 020
	N	29	29	29	29	29 000

Appendix D 2

Data on Samples Collected in Peru

PVO	Location	Product	Contract	Lot	Date	Bag Number	Bag Location	Vitamin A (IU/100g) in Peru
Prisma	El Augustio	Bulgur	01619		9-22-98	1	A	630
Prisma	El Augustio	Bulgur	01619		9-22-98	2	B	620
Prisma	El Augustio	Bulgur	01619		9-22-98	3	C	590
Prisma	El Augustio	Bulgur	01619		9-22-98	4	A	450
Prisma	El Augustio	Bulgur	01619		9-22-98	5	B	650
ADRA	Callao	SF Bulgur	01719	E lot 91	9-23-98	1	A	400
ADRA	Callao	SF Bulgur	01719	W lot 61	9-23-98	2	B	400
ADRA	Callao	SF Bulgur	01719	W lot 36	9-23-98	3	C	730
ADRA	Callao	SF Bulgur	01719	W lot 91	9-23-98	4	A	940
ADRA	Callao	SF Bulgur	01719	K lot 92	9-23-98	5	B	1,530
CARITAS	Lima	Wheat Flour	01761	14	9-25-98	1	A	1,250
CARITAS	Lima	Wheat Flour	01761	14	9-25-98	2	B	1 280
CARITAS	Lima	Wheat Flour	01761	14	9-25-98	3	C	1 220
CARITAS	Lima	Wheat Flour	01761	14	9-25-98	4	A	1,210
CARITAS	Lima	Wheat Flour	01761	14	9-25-98	5	B	1,250
CARITAS	Lima	Wheat Flour	01761	13	9-25-98	6	B	1,200
CARITAS	Lima	Wheat Flour	01761	13	9-25-98	7	A	1 400
CARITAS	Lima	Wheat Flour	01761	13	9-25-98	13	C	1,270
CARITAS	Lima	Wheat Flour	01761	12	9-25-98	8	B	1 320
CARITAS	Lima	Wheat Flour	01761	12	9-25-98	9	A	1,510
CARITAS	Lima	Wheat Flour	01761	12	9-25-98	10	C	1,490
CARITAS	Lima	Wheat Flour	01761	12	9-25-98	11	B	1,370
CARITAS	Lima	Wheat Flour	01761	12	9-25-98	12	A	1,340
CARITAS	Lima	Bulgur	01750	727	9-25-98	1	A	1,910
CARITAS	Lima	Bulgur	01750	727	9-25-98	2	A	780
CARITAS	Lima	Bulgur	01750	727	9-25-98	3	B	2,390
CARITAS	Lima	Bulgur	01750	727	9-25-98	4	C	1 510
CARITAS	Lima	Bulgur	01750	727	9-25-98	5	A	1 370
CARITAS	Lima	Bulgur	01750	727	9-25-98	6	B	2 080
CARITAS	Lima	Bulgur	01750	727	9-25-98	7	C	3,510
CARITAS	Lima	Bulgur	01595	11	9-25-98	8	A	330
CARITAS	Lima	Bulgur	01595	11	9-25-98	9	B	520
CARITAS	Lima	Bulgur	01595	11	9-25-98	10	C	790
CARITAS	Lima	Bulgur	01595	12	9-25-98	11	A	500
CARITAS	Lima	Bulgur	01595	12	9-25-98	12	B	740
CARITAS	Lima	Bulgur	01595	12	9-25-98	13	C	800
CARITAS	Lima	Bulgur	01750	727	9-25-98	14	A	1 580
CARITAS	Lima	Bulgur	01750	727	9-25-98	15	B	1 190
CARITAS	Lima	Bulgur	01750	727	9-25-98	16	C	1,660
CARITAS	Lima	Bulgur	01750	727	9-25-98	17	A	1,030
CARITAS	Lima	Bulgur	01750	727	9-25-98	18	B	1,980
CARITAS	Lima	Bulgur	01750	727	9-25-98	19	C	1,900
CARITAS	Lima	Bulgur	01750	727	9-25-98	20	A	1 010
CARITAS	Lima	Bulgur	01750	727	9-25-98	21	B	990
CARITAS	Lima	Bulgur	01750	727	9-25-98	22	B	1 510
CARITAS	Lima	Bulgur	01750	727	9-25-98	23	C	1 140
CARITAS	Lima	Bulgur	01750	727	9-25-98	24	A	1,150
CARITAS	Lima	Bulgur	01750	727	9-25-98	25	B	1,120
CARITAS	Lima	Bulgur	01750	727	9-25-98	26	C	940
CARITAS	Lima	Bulgur	01750	727	9-25-98	27	A	970

PVO- warehouse sample was taken from
Location- city or town where warehouse is located
Contract- number printed on bag
Lot- number stamped on bag
Date- sample taken on this day
Bag number- arbitrary number for scientific purposes

Bag location- position of the bag the sample was taken from
a- top of the bag
b- middle of the bag
c- bottom of the bag

Appendix D 3
Key for Analytical Data on Cooked Samples

Sample Designation	Identification code of samples
Preparation type	The type of CSB/WSB based meal prepared
Moisture in CSB/WSB Before cooking (% by wt)	Laboratory assay of the moisture content of the uncooked CSB/WSB reported as a percentage of weight
Moisture in food mixture After cooking (% by wt)	Laboratory assay of the moisture of the respected food preparation after cooking, reported as a percentage of weight of the cooked ingredients including CSB/WSB
Vitamin C in CSB/WSB Before cooking, wet basis (mg/100g)	Milligrams of Vitamin C per 100grams of uncooked CSB/WSB based on total weight including moisture
Vitamin C in CSB/WSB Before cooking, dry basis (mg/100g)	Milligrams of Vitamin C per 100 grams of uncooked CSB/WSB based on solid content (calculated by factoring out moisture content)
Vitamin C in food mixture cooking, wet basis (mg/100g)	Milligrams of Vitamin C per 100 grams of cooked food preparation **after** based on total weight (including moisture)
Vitamin C in food mixture cooking, dry basis (mg/100g)	Milligrams of vitamin C per 100 grams of cooked food preparation **after** based on solid content (calculated by factoring out moisture content)
Vitamin C retention dry basis	% Measurement of the degree to which vitamin C remains in prepared food after cooling based on solid content (calculated by comparing vitamin C levels in the cooked food preparation with vitamin C levels in the uncooked CSB/WSB
Time in water before Cooking (min sec)	The length of time CSB/WSB spent in the water before being cooked
Time of cooking (min sec)	The length of time WSB/CSB was cooked
Vitamin C added	The level of vitamin C added
Conventional Vitamin C	Level (40mg/100g)
High Vitamin C	Level (90mg/100g)
Bag Location/Sampled	1 The country in which the sample was taken 2 Which position of the bag the sample was taken from a- top of the bag b- middle of the bag c- bottom of the bag

Appendix D 3

Analytical Data on Cooked Samples of WSB from Haiti - Water, Iron and Niacin

Sample Number	Food Preparation type	Moisture before cooking (% by wt)	Moisture after cooking (% by wt)	Iron in WSB before cooking, wet basis (mg/100g)	Niacin in WSB before cooking, wet basis (mg/100g)	Niacin dry basis before cooking (mg/100g)	Niacin in food mixture after cooking, wet basis (mg/100g)	Niacin dry basis after cooking (mg/100g)	Niacin retention (%)
1	gruel	7 67	79 6	20 5	8 8	9 5	1 3	6 4	67
2	gruel	7 82	73 9	26 3	10 0	10 8	1 7	6 5	60
3	gruel	7 73	79 5	22 0	8 4	9 1	1 5	7 3	80
4	gruel	7 61	77 7	20 8	8 8	9 5	1 9	8 5	89
5	gruel	7 70	76 4	19 9	8 9	9 6	1 6	6 8	70
Average		7 71	77 4			9 7		7 1	73
Standard Deviation		0 08	2 4			0 7		0 9	12
6	dumplings	7 79	59 1	25 6	8 4	9 1	3 0	7 3	81
7	dumplings	7 64	56 3	22 8	8 7	9 4	3 9	8 9	95
8	dumplings	7 62	61 8	20 6	8 5	9 2	2 8	7 3	80
9	dumplings	7 52	64 4	20 7	8 9	9 6	3 3	9 3	96
10	dumplings	7 78	57 7	20 5	8 7	9 4	2 4	5 7	60
Average		7 67	59 9			9 4		7 7	82
Standard Deviation		0 11	3 3			0 2		1 4	15
11	gruel	7 55	81 0	22 6	9 2	10 0	1 6	8 4	85
12	gruel	7 71	83 0	20 4	9 6	10 4	1 3	7 6	74
13	gruel	7 60	79 9	21 2	9 4	10 2	1 5	7 5	73
Average		7 62	81 3	21		10 2		7 8	77
Standard Deviation		0 08	1 6	1		0 2		0 5	6
16	dumplings	7 60	61 0	22 6	9 4	10 2	3 4	8 7	86
17	dumplings	7 98	62 9	21 2	9 4	10 2	3 3	8 9	87
18	dumplings	7 43	59 9	20 5	9 9	10 7	3 2	8 0	75
19	dumplings	7 68	47 5	20 7	9 5	10 3	3 1	5 9	57
Average		7 67	57 8	21		10 3		7 9	76
Standard Deviation		0 23	7 0	1		0 2		1 4	14

Appendix D 3

Analytical Data on Cooked Samples of CSB from Tanzania

Wet CSB Samples

			Times (min)		Final	Other	Product			Assayed Level			Calculated Level			Percent Retention		
Sampl No	CSB (g)	Water (g)	total	cook	Wt (g)	Ingred (g)	Type	CSB %	Water (%)	Vit A (IU/100g)	Vit C (mg/100g)	Niacin (mg/100g)	Vit A (IU/100g)	Vit C (mg/100g)	Niacin (mg/100g)	Vit A (%)	Vit C (%)	Niacin (%)
1	620	2100	7	7			Ugali	22 8	51 4	1210	18	4 3	517	21	1 9	234	84	222
2	370	4400	18	11			Gruel	7 8	92 6	60	4	0 9	168	7	0 7	36	54	135
3	450	2870	9	6			Gruel	13 6	88 4	130	5	1 3	289	12	1 2	45	42	112
4	270	1760	11	8			Gruel	13 3	88 5	90	6	1 3	281	13	1 2	32	47	112
5	530	770	6	4	890		Ugali	40 8	61 0	740	15	3 6	824	39	3 5	90	38	103
6	241	2475		9 5			Gruel	8 9	86 5			0 8	79	3	0 5			167
7	222	1741		8 5			Gruel	11 3	85 0	60		1	105	3	0 6	57		164
8	195	1574		8			Gruel	11 0	89 7			1	72	2	0 6			168
9	843	4690		10 5			Gruel	15 2	89 9	60	1	1	157	4	0 8	38	23	122
10	571	5449		8 5			Gruel	9 5	92 0	50		0 8	79	3	0 5	64		156
11	760	700	5	5	1160		Ugali	52 1	48 1	460	7	3 1	505	12	2 9	91	56	108
12	940	4500	23	20			Gruel	17 3	86 6	80	2	0 9	190	5	1 0	42	43	95
13	450	2300	19	15			Gruel	16 4	81 4	50	2	0 9	144	5	0 9	35	37	100
14	240	1730	11	6			Gruel	12 2	90 7	40	1	0 8	115	3	0 7	35	33	119
15	390	1740	24	12		630	Soup	14 1	80 9	110		0 9	160	4	0 8	69		116
16	724	1095		4	1442		Ugali	39 8	56 0	1800	57	6 3	1 540	64	5 6	117	90	113
17	506	3759	17	15			Gruel	11 9	89 1	200	14	1 6	419	19	1 7	48	74	96
18	250	1653	16 5	16			Gruel	13 1	87 7	390	16	1 7	489	21	1 8	80	76	92
19	791	1049		3 5	1577		Ugali	43 0	57 4	1510	49	5 8	1 603	60	6 0	94	81	96
20	401	3199		29			Gruel	11 1	86 4	260	13	1 5	485	18	1 6	54	73	96
21	410	370	5	5	572		Cake	71 7	39 8	410		3	760	20	3 9	54		76

Appendix D 3

Analytical Data on Cooked Samples of WSB from Haiti - Vitamins A and C

Sample Number	Food Preparation type	Vitamin A in WSB before cooking, wet basis (IU/100g)	Vitamin A dry basis before cooking (IU/100g)	Vitamin A in food mixture after cooking, wet basis (IU/100g)	Vitamin A dry basis after cooking (IU/100g)	Vitamin A retention (%)	Vitamin C wet basis before cooking (mg/100g)	Vitamin C dry basis before cooking (mg/100g)	Vitamin C wet basis after cooking (mg/100g)	Vitamin C dry basis after cooking (mg/100g)	Vitamin C retention (%)
1	gruel	1640	1776	70	343	19	67	73	4	20	27
2	gruel	1760	1909	230	881	46	73	79	7	27	34
3	gruel	1500	1626	220	1 073	66	79	86	6	29	34
4	gruel	1800	1948	210	942	48	81	88	8	36	41
5	gruel	1590	1723	200	847	49	72	78	4	17	22
Average			1796		817	46	74	81	6	26	32
Standard Deviation			133		279	17	6	6	2	8	7
6	dumplings	1800	1952	620	1,516	78	76	82	9	22	27
7	dumplings	1520	1646	730	1,670	102	85	92	22	50	55
8	dumplings	1560	1689	540	1,414	84	66	71	2	5	7
9	dumplings	1900	2054	550	1,545	75	83	90	14	39	44
10	dumplings	1710	1854	350	827	45	82	89	11	26	29
Average			1839		1394	77		85		29	32
Standard Deviation			173		330	21		8		17	18
11	gruel	1740	1882	240	1,263	67	38	41	2	11	26
12	gruel	2240	2427	160	941	39	35	38	2	12	31
13	gruel	1900	2155	140	697	32	38	41	2	10	24
Average			2155		967	46		40		11	27
Standard Deviation			273		284	19		2		1	4
16	dumplings	1790	1937	650	1,667	86	40	43	5	13	30
17	dumplings	1680	1826	690	1 860	102	35	38	2	5	14
18	dumplings	2320	2506	640	1,596	64	37	40	2	5	12
19	dumplings	1750	1896	460	876	46	38	41	3	6	14
Average			2041		1500	65		41		7	18
Standard Deviation			313		430	24		2		4	8

Appendix D 3
Analytical Data on Cooked Samples of WSB from Haiti - Vitamins A and C

DRY CSB SAMPLES Sample No	Vitamin A (IU/100g)	Vitamin C (mg/100g)	Niacin (mg/100g)	Iron (mg/100g)	Moisture (%)	Water Activity (%)
1	2270	94	8 5	17 5	9 66	0 483
2	2170	95	8 6	17 7	9 57	0 476
3	2130	88	8 6	17 3	9 63	0 478
4	2110	96	8 7	16 7	9 74	0 483
5	2020	96	8 6	16 7	9 71	0 481
6	890	36	5 4	25 1	9 46	0 448
7	930	23	5 4	25 3	9 45	0 455
8	650	22	5 4	18 7	9 43	0 449
9	1030	28	5 4	23 5	9 39	0 451
10	830	34	5 4	20 9	9 33	0 436
11	970	24	5 5	28 3	9 62	0 476
12	1100	27	5 5	27 7	9 57	0 469
13	880	33	5 5	27 7	9 57	0 479
14	940	25	5 5	28 0	9 50	0 468
15	1130	29	5 5	26 4	9 63	0 466
16	3870	160	14	32 8	9 53	0 488
17	3530	160	14	32 6	9 52	0 477
18	3720	160	14	36 1	9 57	0 478
19	3730	140	14	33 8	9 55	0 484
20	4350	160	14	37 0	9 55	0 479
21	1060	28	5 5	28 0	9 81	0 477

Appendix D 3

Summary of Vitamin C and A Content of the WSB and CSB After Cooking

Commodity	Type of Food Preparation	Number of samples	Vitamin C Level	Serving Size (Cooked) Estimate	Vitamin C in Cooked Food (mean in mg/100g)	Vitamin C Content Estimate (mg/Serving)	Vitamin A in Cooked Food (mean in IU/100g)	Vitamin A Content Estimate (IU/Serving)
WSB	Gruel	3	conventional	150 g	2 mg/100g of gruel	3 mg/serving	180	270
	Gruel	5	high	150 g	6 mg/100g of gruel	9 mg/serving	186	279
	Dumplings	4	Conventional	40 g	3 mg/100g of dumplings	1 2 mg/serving	610	244
	Dumplings	5	high	40 g	12 mg/100g of dumplings	4 8 mg/serving	558	223
CSB	gruel	8	conventional	150 g	<1 mg/100g of gruel	< 1 5 mg/serving	43	64
	Gruel	6	high (several levels)	150 g	4–16 mg/100g of gruel	6-24 mg/serving	188	282

Appendix D 4

Within Bag Analytical Data

Sample Designation	Identification code of samples, including lot number, location and part of the bag where the sample was taken
Assay	Nutrient content measured by the laboratory analysis
Vitamin C assay	Results of measures for milligrams of vitamin C per 100 grams of commodity
Niacin assay	Results of measures for milligrams of niacin per 100 grams of commodity
Moisture assay	Results of measures for grams of water 100 grams of commodity
Water Activity assay	Ratio of the vapor pressure of water in equilibrium with food and the vapor pressure of pure water at the same temperature
Iron	Results of measures for milligrams of iron per 100 grams of commodity
Vitamin A	Results of measures for milligrams of vitamin A per 100 grams of commodity
Sample Number	Identification code of samples that can include lot number, sampling, date, sampling time, etc
Vitamin C added	The level of vitamin C added,
Conventional Vitamin C	Level (40mg/100g)
High Vitamin C	Level (90mg/100g)
Sampled/ Bag Location	1 The country in which the sample was taken 2 Which position of the bag the sample was taken from a- top of the bag b- middle of the bag c- bottom of the bag

Appendix D 4

Within Bag Samples of WSB Collected in Haiti

Sample Number	WATER (%)	VITAMIN A (IU/100g)	ASSAY VITAMIN C (mg/100g)	NIACIN (mg/100g)	VITAMIN C level added
CSB2a011897H	10 20	990	29	5 3	High
CSB2b011897H	10 20	980	29		
CSB2c011897H	10 20	1020	31		
Bag Average	10 20	997	30		
CSB5a011897C	9 59	1020	27	5 1	Conventional
CSB5b011897C	9 59	1120	16		
CSB5c011897C	9 59	1020	26		
Bag Average	9 59	1053	23		
CSB6a011897C	9 04	460	6	3 6	Conventional
CSB6b011897C	9 20	290	7		
CSB6c011897C	9 32	400	14		
Bag Average	9 19	383	9		
CSBVEPE00393a901	9 65	1530	31	17 6	Conventional
CSBVEPE00393b901	9 71	1860	30		
CSBVEPE00393c901	9 72	1380	36		
Bag Average	9 69	1590	32		
CSBVEPE00393a915	10 50	1700	32	22 8	Conventional
CSBVEPE00393b915	10 40	1350	22		
CSBVEPE00393c915	10 40	2410	31		
Bag Average	10 43	1820	28		
CSBVEPE00343a929	10 10	920	31	15 2	Conventional
CSBVEPE00343b929	10 10	1530	35		
CSBVEPE00343c929	10 10	2540	34		
Bag Average	10 10	1663	33		
CSBVEPE00393a940	9 90	850	16	4 3	Conventional
CSBVEPE00393b940	9 84	1260	21		
CSBVEPE00393c940	9 87	610	20		

Appendix D 4

Within Bag Samples of WSB Collected in Haiti

Sample Number	WATER (%)	VITAMIN A (IU/100g)	ASSAY VITAMIN C (mg/100g)	NIACIN (mg/100g)	VITAMIN C level added
Bag Average	9 87	907	19		
CSBVEPE00393a966	8 96	1590	39	25 6	Conventional
CSBVEPE00393b966	9 64	1640	31		
CSBVEPE00393c966	8 80	2780	35		
Bag Average	9 13	2003	35		
CSB012097H1Da01	9 66	2270	94	8 5	High
CSB012097H1Db02	9 57	2170	95		
CSB012097H1Dc03	9 63	2130	88		
CSB012097H1Da04	9 74	2110	96	8 7	
CSB012097H1Db05	9 71	2020	96		
Bag Average	9 66	2140	94	8 6	
Frozen retained sample		2900	113	8 7	
CSB012197C6Da11	9 62	970	24	5 5	Conventional
CSB012197C6Db12	9 57	1100	27		
CSB012197C6Dc13	9 57	880	33	5 5	
CSB012197C6Da14	9 50	940	25		
CSB012197C6Db15	9 63	1130	29		
CSB012197C6Dc21	9 81	1060	28		
Bag Average	9 62	1013	28	5 5	
CSB012197H2Da16	9 53	3870	160	14 0	High
CSB012197H2Db17	9 52	3530	160		
CSB012197H2Dc18	9 57	3720	160		
CSB012197H2Db19	9 55	3730	140		
CSB012197H2Dc20	9 55	4350	160		
Bag Average	9 544	3840	156	14	
CSB1a011897H	10 00	630	15	3 8	High
CSB1b011897H	10 00	580	13		
CSB1c011897H	9 74	800	21		
Bag Average	9 91	670	16		

Appendix D 4

WSB samples in Haiti taken from different points in the bag

Number	day/time	C Level	Sampled	Moisture	Vitamin A	Vitamin C	Iron	Niacin
1005	8 830	Conv	Production		2700	45		11 0
			Haiti a	7 68	1750	38	20 7	9 5
			Haiti b	7 60	1900	38	21 2	9 4
			Haiti c	7 60	1970	35	20 3	9 6
			mean	7 63	1873	37	20 7	9 5
			change					
2023	8 1405	Conv	Production		2830	44		9 5
			Haiti -a	7 98	1680	35	21 2	9 4
			Haiti -b	7 67	2320	35	20 8	9 8
			Haiti -c	7 79	2480	36	20 2	9 1
			mean	7 81	2160	35	20 7	9 4
			change					
3045	9 950	Conv	Production		2810	41		9 6
			Haiti -a	7 71	2240	35	20 3	9 6
			Haiti -b	7 43	2320	37	20 4	9 9
			Haiti c	7 45	2340	33	20 4	9 4
			mean	7 53	2300	35	20 4	9 6
			change					
4078	10 945	Conv	Production		3140	44		9 5
			Haiti -a	8 01	2020	38	22 6	9 2
			Haiti -b	7 55	1740	40	22 6	9 4
			Haiti c	7 60	1790	35	21 2	9 4
			mean	7 72	1850	38	22 1	9 3
			change					
5092	10 1500	High	Production					
			Haiti a	7 82	1760	73	26 3	10 0
			Haiti b	7 79	1800	76	25 6	8 4
			Haiti c	7 84	1620	79	26 8	8 3
			mean	7 82	1727	76	26 2	8 9
			change					
6114	11 905	High	Production		2650	71		9 3
			Haiti a	7 73	1500	79	22 0	8 4
			Haiti b	7 64	1520	85	22 8	8 7
			Haiti -c	7 69	1590	82	22 0	8 1
			mean	7 69	1537	82	22 3	8 4
			change					
7147	12 945	High	Production		2290	78		8 9
			Haiti -a	7 85	1600	78	20 7	9 0
			Haiti b	7 62	1520	63	21 2	8 9
			Haiti c	7 67	1640	67	20 5	8 8
			mean	7 71	1587	69	20 8	8 9
			change					
8153	12 1110	High	Production		2550	67		11 0
			Haiti a	7 73	1790	63	21 0	9 8
			Haiti b	7 61	1800	81	20 8	8 8
			Haiti c	7 62	1560	66	20 6	8 5
			mean	7 65	1717	70	20 8	9 0
			change					
8155	12-1125	High	Production		2570	60		9 4
			Haiti -a	7 70	1590	72	19 9	8 9
			Haiti -b	7 52	1900	83	20 7	8 9
			Haiti c	7 56	1650	83	20 3	8 9
			Haiti a	7 78	1590	82	20 5	8 7
		mean change		7 62	1713	83	20 5	8 8

Appendix D 4

Corn Soy Blend samples in Tanzania taken from different parts of bags

Sample Number	Bag Location Sampled	Moisture %	Vitamin A IU/100g	Vitamin C mg/100g	Niacin mg/100g	Iron mg/100g	Water Actvity %
CSBVEPE00393a901	a-Top	9 65	1530	31	6 1	17 6	0 466
CSBVEPE00393b901	b-Middle	9 71	1860	30		18 0	0 481
CSBVEPE00393c901	c-bottom	9 72	1380	36		17 5	0 473
CSBVEPE00393a915	Top	10 50	1700	32	5 9	22 8	0 510
CSBVEPE00393b915	Middle	10 40	1350	22		23 3	0 499
CSBVEPE00393c915	Bottom	10 40	2410	31		23 0	0 528
CSBVEPE00343a929	Top	10 10	920	31	5 3	15 2	0 492
CSBVEPE00343b929	Middle	10 10	1530	35		15 1	0 509
CSBVEPE00343c929	Bottom	10 10	2540	34		15 1	0 479
CSBVEPE00393a940	Top	9 90	850	16	4 3	15 1	0 476
CSBVEPE00393b940	Middle	9 84	1260	21		16 1	0 487
CSBVEPE00393c940	Bottom	9 87	610	20		16 2	0 485
CSBVEPE00393a947	Top	9 41	1970	42	6 2	15 6	0 461
CSBVEPE00393b947	Middle	9 74	2710	35		17 9	0 470
CSBVEPE00393c947	Bottom	9 64	1640	31		16 4	0 469
CSBVEPE00393a953	Top	9 16	1840	48	5 9	16 8	0 431
CSBVEPE00393b953	Middle	9 24	1300	31		16 4	0 432
CSBVEPE00393c953	Bottom	9 21	3280	41		16 4	0 424
CSBVEPE00393a966	Top	8 96	1590	39	7 4	25 6	0 431
CSBVEPE00393b966	Middle	9 64	1640	31		28 3	0 469
CSBVEPE00393c966	Bottom	8 80	2780	35		30 0	0 452
CSB1a011897H	Top	10 00	630	15	3 8	10 0	0 489
CSB1b011897H	Middle	10 00	580	13		11 1	0 491
CSB1c011897H	Bottom	9 74	800	21		13 5	0 485
CSB2a011897H	Top	10 20	990	29	5 3	16 8	0 512
CSB2b011897H	Middle	10 20	980	29		17 4	0 509
CSB2c011897H	Bottom	10 20	1020	31		19 1	0 522
CSB5a011897C	Top	9 59	1020	27	5 1	26 6	0 463
CSB5b011897C	Middle	9 59	1120	16		24 9	0 433
CSB5c011897C	Bottom	9 59	1020	26		27 9	0 463
CSB6a011897C	Top	9 04	460	6	3 6	11 6	0 430
CSB6b011897C	Middle	9 20	290	7		11 4	0 437
CSB6c011897C	Bottom	9 32	400	14		16 9	0 431

Appendix D 5
Analytical Data on Frozen Samples

Effect of Freezing on CSB Samples from Plant C

Sample Number	Vitamin C (mg/100g) at production	after frozen	Vitamin A (IU/100g) at production	after frozen
229			1940	1920
230	35	32		
222	40	34	2440	2370
224	37	35	1690	2330
219	32	36	2230	2320
220	39	38	2250	2430
205	35	39	2500	2290
221	45	40	2280	2180
226	49	43	1810	2110
Average	39 0	37 1	2,143	2,244
Std Dev	5 3	3 3	276	155
Number of Samples	8	8	8	8

Samples keep frozen 5 months between tests

Effect of Freezing on WSB Samples from Plant B

Sample Number	Vitamin C (mg/100g) at production	after frozen	Vitamin A (IU/100g) at production	after frozen
5	45	39	2700	2400
23	44	45	2830	2910
31	42	41	2650	2530
36	38	42	2550	2210
45	41	44	2810	2610
78	44	40	3140	2590
92	82	79	2360	2280
114	71	79	2340	2250
118			2480	2250
147	78	79		
Average	53 9	54 2	2651	2448
Std Dev	16 7	17 6	240	219
Number of Samples	9	9	9	9

Samples keep frozen 9 months between tests

Vitamin C assay Results of measures for milligrams of vitamin C per 100 grams of commodity
Vitamin A Results of measures for milligrams of Vitamin A per 100 grams of commodity
IU International Unit
Sample Number Identification code of samples

APPENDIX D 6:
Analytical Data on Micronutrient Premix Samples

Appendix D 6
Vitamin Premix Analysis

Date Sampled	Type	Mfg	Plant Used at	Vitamin C			Niacin		Vitamin A	
				Lab A	Lab B	% of target	Lab A	% of target	Lab A	% of target
				(%)	(%)	(%)	(%)	(%)	(IU/g)	(%)
6-24-96	H	W	A	60 0	57 3	97 5%	3 68	111 4%	15,987	103 7%
6-25-96	H	W	A	62 6	59 2	101 3%	3 12	94 4%	15 766	102 3%
6-26-96	H	W	A		55 7	92 6%				
6-27-96	C	W	A	40 3	38 8	98 7%	5 20	104 9%	25,623	110 8%
7-8-96	C	P	B	41 7	43 1	105 8%	5 04	101 7%	25,689	111 1%
7-10-96	C	P	A	40 8	44 2	106 0%	4 93	99 5%	24,587	106 3%
7-10-96	H	W	A		63 0	104 8%				
7-11-96	H	W	A	55 4	58 8	95 0%	3 27	99 0%	16,097	104 4%
7-12-96	H	W	A	55 6	58 8	95 1%	3 40	102 9%	15 987	103 7%
10-8-96	C	W	C	43 4		108 3%			23300	100 7%
10-9-96	C	W	C	43 4		108 3%			21700	93 8%
10-15-96	C	W	C	41 4		103 3%			22000	95 1%
10-16-96	C	W	D	40 9		102 0%			22500	97 3%
1-29-97	C	W	D	38 9		97 0%			24500	105 9%
1-30-97	C	W	D	37 8		94 3%			21700	93 8%
1-31-97	C	W	D	38 2		95 3%			25000	108 1%
TARGET	H			60 13			3 30		15 419	
TARGET	C			40 09			4 96		23,128	
V/M Mix	C	W	A	1 50		104 7%	0 180	101 7%	86 90	105 2%
			TARGET	1 43			0 177		82 64	

Key to Table
H = High vitamin C premix
C = Conventional vitamin C premix

W = Watson Enrichment Products Inc
P = ADM Paniplus Company

Lab A = Watson Foods
Lab B = American Ingredients

Appendix D 7

Key for Analytical Data on Plant Samples

Vitamin C assay	Results of measures for milligrams of vitamin C per 100 grams of commodity
Niacin assay	Results of measures for milligrams of niacin per 100 grams of commodity
Iron assay	Results of measures for milligrams of Iron per 100 grams of commodity
Vitamin A assay	Results of measures for milligrams of Vitamin A per 100 grams of commodity
Conventional Vitamin C	Level (40mg/100g)
High Vitamin C	Level (90mg/100g)
Sampled	1 The country in which the sample was taken 2 Which position of the bag the sample was taken from a- top of the bag b- middle of the bag c- bottom of the bag
Sample Designation/ Number	Identification code of samples
Lot	Number Stamped on bag
Time	Time of day sample was taken
Day	Date sample was taken
Line	Plant D has two lines going to different packout stations, these are designated line A and line B
Shift	Some plants have only one working shift while others have two or three Each shift is usually manned by a different group of personnel

Appendix D 7

Analytical Data on CSB made with Conventional Level of Vitamin C from Plant A

SAMPLE				**Vitamin C**	**(mg/100g)**
No	Time	Day	Lot	Assay	Check
102	1530	26-Jun	5	37	
103	1600	26-Jun	5	24	
105	1645	26-Jun	5	27	
104	1650	26-Jun	5	26	
108	1800	26-Jun	5	31	
116	2000	26-Jun	5	29	
115	2020	26-Jun	5	14	24
118	2030	26-Jun	5	31	
119	2100	26-Jun	5	12	
120	2130	26-Jun	5	39	
121	2200	26-Jun	5	25	
123	700	27-Jun	6	10	10
124	730	27-Jun	6	33	
125	800	27-Jun	6	20	12
127	900	27-Jun	6	23	23
128	945	27-Jun	6	7	
129	1000	27-Jun	6	15	
132	1115	27-Jun	6	69	49
134	1200	27-Jun	6	22	35
136	1315	27-Jun	6	23	
138	1400	27-Jun	6	290	
141	1420	27-Jun	6	47	
155	1540	27-Jun	7	11	
142	1615	27-Jun	7	13	16
143	1625	27-Jun	7	11	
144	1630	27-Jun	7	11	
145	1745	27-Jun	7	26	
146	1800	27-Jun	7	11	
148	1845	27-Jun	7	1	
149	1900	27-Jun	7	2	2
150	2000	27-Jun	7	22	
151	2015	27-Jun	7	33	
169	2100	27-Jun	7	72	
165	2130	27-Jun	7	60	
164	2200	27-Jun	7	53	
153	2230	27-Jun	7	41	
163	600	28-Jun	8	38	
162	700	28-Jun	8	51	38
170	815	28-Jun	8	25	9
172	840	28-Jun	8	14	
175	1100	28-Jun	8	23	
174	1130	28-Jun	8	22	
177	1140	28-Jun	8	24	
179	1200	28-Jun	8	31	
			Average	33 0	21 8
			Std Dev	42 8	14 2
			Number	44	10

Appendix D 7

Analytical Data on WSB Made with Conventional Level of Vitamin C from Plant B

SAMPLE				Vitamin C (mg/100g)				Niacin (mg/100g)		Vitamin A (IU/100g)			
No	Time	Day	Lot	Assay	Check	Rerun	in Haiti	Assay	Check	Assay	Check	Rerun	in Haiti
1	715	8-Jul	1				35	10 0		2980			1680
2	720	8-Jul	1	43				10 0		3170			
3	745	8-Jul	1					11 0		3320			
4	750	8-Jul	1	44			40	9 3		2500			
5	830	8-Jul	1	45		39	38	11 0		2700		2400	1750
6	915	8-Jul	1	39			43	9 3		2850			1710
7	940	8-Jul	1	50	39		37	10 0	9 7	2980	3320		1820
10	1010	8-Jul	1	40	38			9 7	10	2920	3420		
11	1030	8-Jul	1	32			40	10 0		3070			1540
12	1045	8-Jul	1	52			38	9 6		2340			1690
13	1150	8-Jul	2	48			39	9 8		2540			2450
14	1235	8-Jul	2	41				9 8		2860			
15	1240	8-Jul	2	53	55			9 8	9 8	2760	2750		
17	1310	8-Jul	2	47			35	9 7		3090			1580
20	1335	8-Jul	2	45	39		38	9 9	10	2740	3030		1740
22	1340	8-Jul	2	45				9 2		2690			
23	1405	8-Jul	2	44		45	35	9 5		2830		2910	1680
24	1410	8-Jul	2				40						1980
26	1425	8-Jul	2	40			38	9 2		2890			1840
28	1450	8-Jul	2	37			38	9 3		2780			1810
29	1500	8-Jul	2				36						1810
30	1505	8-Jul	2	38				8 9		2940			
31	1515	8-Jul	2	42		41	35	9 5		2650		2530	1580
35	715	9-Jul	2	35				9 7		3090			
36	730	9-Jul	2	38		42	34	9 4		2550		2210	1690
38	750	9-Jul	3	38	42		41	9 5	9 5	2680	2700		1960
39	820	9-Jul	3	44	36			9 7	9 7	2850	2830		
41	855	9-Jul	3	47			41	10 0		2940			
45	950	9-Jul	3	41	40	44	35	9 6	9 5	2810	2820	2610	2240
47	1015	9-Jul	3	47				10 0		3060			
49	1035	9-Jul	3	44			40	9 4		3130			1870
50	1045	9-Jul	3	49			37	10 0		2610			1750
52	1050	9-Jul	3	48				9 1		3210			
53	1105	9-Jul	3	43	40		37	10 0	8 9	2620	2830		1610
55	1120	9-Jul	3	43			35	9 5		2870	1700		
57	1140	9-Jul	3	36				9 2		2820			
59	1240	9-Jul	3	50			37	9 3		3260			1960
61	1315	9-Jul	3	40			34	9 4		2780			1890
64	1345	9-Jul	3	43	40			10 0	9 2	3270	3520		
67	1410	9-Jul	4	39			38	9 2		3410			1930
68	1415	9-Jul	4	39				9 6		3430			
71	740	10-Jul	4	45				9 1		3790			
74	825	10-Jul	4	38				10 0		3690			
75	850	10-Jul	4	39				9 0		2980			
76	900	10-Jul	4	37			40	10 0		3380			1990

Appendix D 7

Analytical Data on WSB Made with Conventional Level of Vitamin C from Plant B

SAMPLE				Vitamin C (mg/100g)				Niacin (mg/100g)		Vitamin A (IU/100g)			
78	945	10-Jul	4	44		40	36	9 5		3140		2590	2020
80	1130	10-Jul	5	60				9 7		2840			
82	1145	10-Jul	5	93	73			11 0	9 2	2430	3260		
86	1235	10-Jul	5	85				9 4		2770			
90	1445	10-Jul	5	87			69	8 6		2540			
91	1450	10-Jul	5	76			80	9 0		2090			
92	1500	10-Jul	5	82		79				2360		2280	1620
97	1250	10-Jul	5	72	74			8 6	8 6	2700	2930		
100	1305	10-Jul	5	88	90			9 9	8 8	2790	2740		
102	1330	10-Jul	5	89			76	8 3		2780			
103	1335	10-Jul	5				71						
105	1350	10-Jul	5	63	70			9 7	9 1	2570	2750		
107	1405	10-Jul	5	66			92	9 0		2590			
108	1420	10-Jul	5	61				9 0		2230			
110	710	11-Jul	5	88			85	10 0		2100			
111	730	11-Jul	5	100			91	9 3		2640			1590
112	805	11-Jul	5	92				9 3		2400			
		Mean		42 7	41 0	41 8	37 6	9 7	9 6	2954	2892	2542	1830
		Std Dev		4 7	5 2	2 1	2 3	0 44	0 3	306	486	213	202
		Number		42	9	6	29	11 00	9	3790	10	6	26

Appendix D.7

Analytical Data on CSB from Plant C

SAMPLE						Vitamin C (mg/100g)			Vitamin A (IU/100g)			Niacin (mg/100g)		Iron (mg/100g)	
No	Day	Time	Line	Lot	bag No	Assay	Check	Retest	Assay	Check	Retest	Assa	Check	Assay	Check
201	9-Oct	700	B	AA	60	30			2600			6 7		13 9	
202	9-Oct	715	A	AA	233	52			2660			6 1		17 6	
203	9-Oct	725	A	AA	450	38	37		2240	2450		6 2	6 2	19 6	19 5
206	9-Oct	745	B	AA	780	31			2310			6 3		16 0	
205	9-Oct	810	A	AA	1240	35		39	2500		2290	6 3		19 1	
207	9-Oct	825	B	AA	1450	45			1940			6 0		19 6	
209	9-Oct	835	B	AA	1600	39	40		2250	2100		6 2	6 2	16 8	16 7
210	9-Oct	850	A	AA	1880	32			2110			6 7		18 8	
211	9-Oct	900	B	AA	2080	34			2140			6 4		18 4	
212	9-Oct	915	A	AA	2400	38	38		2110	2270		6 3	6 5	20 0	19 6
214	9-Oct	950	B	AA	2700	38			2280			7 0		25 9	
215	9-Oct	1005	A	AB	165	34			2110			6 1		22 4	
216	9-Oct	1020	B	AB	420	49			2600			6 0		21 1	
218	9-Oct	1030	B	AB	450	37	43		2080	1820		6 7	5 6	26 9	26 0
219	9-Oct	1050	A	AB	950	32		36	2230		2320	5 9		23 6	
220	9-Oct	1105	A	AB	1205	39		38	2250		2430	6 2		26 1	
221	9-Oct	1115	A	AB	1365	45		40	2280		2180	6 3		23 6	
222	9-Oct	1125	A	AB	1500	40	40	34	2440	1900	2370	6 1	6 4		21 9
224	9-Oct	1220	A	AB	1950	37		35	1690		2330	5 9		28 3	
225	9-Oct	1225	B	AB	2200	34			1880			6 5		30 9	
226	9-Oct	1235	A	AB	2270	49		43	1810		2110	6 0		21 9	
228	9-Oct	1240	B	AB	2400	39			1960			5 9		21 4	
227	9-Oct	1245	B	AB	2440	42			1860			6 2		21 0	
230	9-Oct	1255	A	AB	2540	35		32	1860			5 8		10 7	
229	9-Oct	1300	B	AB	2700	36			1940		1920	6 2		23 1	
233	16-Oct	730	A	AC	125	43			2330			6 2		15 2	
234	16-Oct	745	B	AC	435	34			1670			6 3		16 0	
235	16-Oct	800	A	AC	670	39			1890			6 0		14 4	
236	16-Oct	815	A	AC	900	50	47		2000	2100		6 2	6 4	18 0	17 2
238	16-Oct	830	B	AC	1150	43			1950			6 8		17 6	
239	16-Oct	850	A	AC	1470	38			2110			6 7		18 7	
240	16-Oct	915	B	AC	1900	35			1950			6 3		17 6	
242	16-Oct	1010	A	AC	2430	35			1860			6 6		28 0	
243	16-Oct	1030	B	AD	50	28	27		2010	1930		6 7	7 0	24 7	25 1
245	16-Oct	1045	A	AD	285	27			2030			6 8		21 6	
246	16-Oct	1055	B	AD	485	25			2150			7 0		22 6	
247	16-Oct	1105	A	AD	660	32			2240			6 7		22 0	
248	16-Oct	1115	B	AD	850	27			2240			6 8		22 4	
249	16-Oct	1130	A	AD	1050	32			2080			6 8		28 0	
251	16-Oct	1215	A	AD	1250	29	28		2100	1980		7 0	6 5	25 4	24 4
250	16-Oct	1225	B	AD	1385	46			2180			6 7		17 2	
253	16-Oct	1240	A	AD	1545	42			1840			5 7		15 6	
255	16-Oct	1305	A	AD	1865	38			1830			5 8		15 5	
256	16-Oct	1320	B	AD	2050	33			2050			6 2		11 6	
257	16-Oct	1325	A	AD	2270	37	37		2270	2110		6 8	6 7	17 2	16 8
259	16-Oct	1350	B	AD	2595	40			2240			6 2		15 6	
260	16-Oct	1400	B	AD	2700	27			2040			6 6		16 0	
					Average	37 0	37 4		2110	2073		6 4	6 4	20 2	20 8
					Std Dev	6 3	6 1		227	185		0 4	0 4	4 6	3 5
					Number	47	9		47	9		47	9	46	9

Appendix D 7

Analytical Data on WSB Made with High Level of Vitamin C from Plant B

SAMPLE				Vitamin C (mg/100g)				Niacin (mg/100g)		Vitamin A (IU/100g)			
No	Time	Day	Lot	Assay	Check	Rerun	in Haiti	Assay	Check	Assay	Check	Rerun	in Haiti
113	840	11-Jul	6	86				8 4		2340			
114	905	11-Jul	6	71		79	79	9 3		2340		2250	1500
115	935	11-Jul	6	66			95	9 3		1870			
116	1010	11-Jul	6	69			100	9 0		2310			
117	1015	11-Jul	6	83				9 3		2010			
118	1030	11-Jul	6	63	65			9 0	8 7	2480	2340	2250	
119	1345	11-Jul	7	64			81	9 4		2070			
121	1110	11-Jul	6	74	89		74	8 8	10	2670	2320		
123	1140	11-Jul	6	58			63	10 0		2160			
124	1245	11-Jul	7	63	66			8 4	8 2	2210	2450		
125	1315	11-Jul	7	71	81			8 5	8 6	2690	2640		
126	1420	11-Jul	6	98				8 5		2560			
127	1425	11-Jul	6					7 8		2120			
129	1435	11-Jul	6	84			72	8 2		2320			1540
130	755	12-Jul	7	76			70	8 8		2270			
131	820	12-Jul	7	67			70	8 7		2530			
132	850	12-Jul	7	82			95	8 4		2230			
133	855	12-Jul	7				64						
134	745	12-Jul	7	72	66		92	8 4	8 6	2650	2490		
137	730	12-Jul	7	88			72	8 3		2270			
138	1450	12-Jul	6	69			81	8 4		2160			
139	1445	12-Jul	6				98						
140	1440	12-Jul	6	88			88	9 0		2560			
141	1435	12-Jul	6	79			66	9 2		2220			1510
142	910	12-Jul	7	66	75			8 7	8 3	2380	2090		
145	925	12-Jul	7	70				9 5		2310			
147	945	12-Jul	7	78		79	78	8 9		2290			1600
149	1030	12-Jul	8	77			82	8 9		2310			
151	1045	12-Jul	8	79				9 4		2210			
153	1110	12-Jul	8	67		85	63	11 0		2550			1790
154	1115	12-Jul	8				75						1470
155	1125	12-Jul	8	60		77	72	9 4		2570			1590
156	1155	12-Jul	8	75				8 8		2410			
157	1250	12-Jul	8	84		87	76	10 0		2780			1280
158	1310	12-Jul	8	79	85			9 1	9 3	2540	2320		
160	1345	12-Jul	8	83			99	9 3		2260			
162	1415	12-Jul	8	66				9 6		2320			
		Mean		76 2	75 8	81 0	79 6	9 1	8 9	2404	2575	2260	1549
		Std Dev		10 7	8 7	3 7	11 0	0 6	0 5	229	316	14	123
		Number		48	11	6	31	48	11	49	11	3	10

Appendix D 7
Analytical Data on CSB from Plant C

SAMPLE						Vitamin C (mg/100g)			Vitamin A (IU/100g)			Niacin (mg/100g)		Iron (mg/100g)	
No	Day	Time	Line	Lot	bag No	Assay	Check	Retest	Assay	Chec	Retest	Assa	Check	Assay	Check
201	9-Oct	700	B	AA	60	30			2600			6 7		13 9	
202	9-Oct	715	A	AA	233	52			2660			6 1		17 6	
203	9-Oct	725	A	AA	450	38	37		2240	2450		6 2	6 2	19 6	19 5
206	9-Oct	745	B	AA	780	31			2310			6 3		16 0	
205	9-Oct	810	A	AA	1240	35		39	2500		2290	6 3		19 1	
207	9-Oct	825	B	AA	1450	45			1940			6 0		19 6	
209	9-Oct	835	B	AA	1600	39	40		2250	2100		6 2	6 2	16 8	16 7
210	9-Oct	850	A	AA	1880	32			2110			6 7		18 8	
211	9-Oct	900	B	AA	2080	34			2140			6 4		18 4	
212	9-Oct	915	A	AA	2400	38	38		2110	2270		6 3	6 5	20 0	19 6
214	9-Oct	950	B	AA	2700	38			2280			7 0		25 9	
215	9-Oct	1005	A	AB	165	34			2110			6 1		22 4	
216	9-Oct	1020	B	AB	420	49			2600			6 0		21 1	
218	9-Oct	1030	B	AB	450	37	43		2080	1820		6 7	5 6	26 9	26 0
219	9-Oct	1050	A	AB	950	32		36	2230		2320	5 9		23 6	
220	9-Oct	1105	A	AB	1205	39		38	2250		2430	6 2		26 1	
221	9-Oct	1115	A	AB	1365	45		40	2280		2180	6 3		23 6	
222	9-Oct	1125	A	AB	1500	40	40	34	2440	1900	2370	6 1	6 4		21 9
224	9-Oct	1220	A	AB	1950	37		35	1690		2330	5 9		28 3	
225	9-Oct	1225	B	AB	2200	34			1880			6 5		30 9	
226	9-Oct	1235	A	AB	2270	49		43	1810		2110	6 0		21 9	
228	9-Oct	1240	B	AB	2400	39			1960			5 9		21 4	
227	9-Oct	1245	B	AB	2440	42			1860			6 2		21 0	
230	9-Oct	1255	A	AB	2540	35		32	1860			5 8		10 7	
229	9-Oct	1300	B	AB	2700	36			1940		1920	6 2		23 1	
233	16-Oct	730	A	AC	125	43			2330			6 2		15 2	
234	16-Oct	745	B	AC	435	34			1670			6 3		16 0	
235	16-Oct	800	A	AC	670	39			1890			6 0		14 4	
236	16-Oct	815	A	AC	900	50	47		2000	2100		6 2	6 4	18 0	17 2
238	16-Oct	830	B	AC	1150	43			1950			6 8		17 6	
239	16-Oct	850	A	AC	1470	38			2110			6 7		18 7	
240	16-Oct	915	B	AC	1900	35			1950			6 3		17 6	
242	16-Oct	1010	A	AC	2430	35			1860			6 6		28 0	
243	16-Oct	1030	B	AD	50	28	27		2010	1930		6 7	7 0	24 7	25 1
245	16-Oct	1045	A	AD	285	27			2030			6 8		21 6	
246	16-Oct	1055	B	AD	485	25			2150			7 0		22 6	
247	16-Oct	1105	A	AD	660	32			2240			6 7		22 0	
248	16-Oct	1115	B	AD	850	27			2240			6 8		22 4	
249	16-Oct	1130	A	AD	1050	32			2080			6 8		28 0	
251	16-Oct	1215	A	AD	1250	29	28		2100	1980		7 0	6 5	25 4	24 4
250	16-Oct	1225	B	AD	1385	46			2180			6 7		17 2	
253	16-Oct	1240	A	AD	1545	42			1840			5 7		15 6	
255	16-Oct	1305	A	AD	1865	38			1830			5 8		15 5	
256	16-Oct	1320	B	AD	2050	33			2050			6 2		11 6	
257	16-Oct	1325	A	AD	2270	37	37		2270	2110		6 8	6 7	17 2	16 8
259	16-Oct	1350	B	AD	2595	40			2240			6 2		15 6	
260	16-Oct	1400	B	AD	2700	27			2040			6 6		16 0	
					Average	37 0	37 4		2110	2073		6 4	6 4	20 2	20 8
					Std Dev	6 3	6 1		227	185		0 4	0 4	4 6	3 5
					Number	47	9		47	9		47	9	46	9

Appendix D 7

Analytical Data on CSB from Plant D

SAMPLE					Vitamin C (mg/100g)		Vitamin A (IU/100g)	
No	Day	Time	Line	Lot	Assay	Check	Assay	Check
359	29-Jan	1400	A	957	33		2120	
301	29-Jan	1515	A	957	33		2220	
302	29-Jan	1555	A	957	27	36	1520	1460
357	29-Jan	1600	A	907	22		1270	
303	29-Jan	1730	A	905	29		1730	
304	29-Jan	1835	A	905	30		1730	
358	30-Jan	600	B	906	27		1180	
305	30-Jan	720	B	906	30		2480	
306	30-Jan	840	A	907	31		2710	
307	30-Jan	950	A	907	32	43	1870	1690
308	30-Jan	1340	A	907	27		1540	
309	30-Jan	1400	A	907	23		1340	
310	30-Jan	1425	A	907	28	32	1530	1580
311	30-Jan	1510	A	907	25		1390	
312	30-Jan	1525	A	907	29		1050	
313	30-Jan	1555	A	907	34		1230	
314	30-Jan	1645	A	907	28	25	1570	1800
315	30-Jan	1750	A	907	14	13	990	840
316	30-Jan	1805	A	907	7		260	
317	30-Jan	1820	A	907	9		590	
318	30-Jan	1840	A	907	26		1230	
320	31-Jan	725	A	908	16		960	1110
321	31-Jan	740	A	908	12		770	
322	31-Jan	800	A	908	36	30	1860	1350
328	31-Jan	820	A	908	32		1640	
329	31-Jan	835	A	908	31	34	1630	1550
330	31-Jan	855	A	908	31		2020	
331	31-Jan	955	A	908	22		1250	
332	31-Jan	1010	A	908	28		1780	
333	31-Jan	1025	A	908	28		1920	
334	31-Jan	1045	A	908	22	30	1900	2080
356	31-Jan	1120	A	908	30		1790	
340	31-Jan	1205	A	908	38		2070	
341	31-Jan	1230	A	908	39	36	1660	1870
343	31-Jan	1255	A	908	36		1800	
344	31-Jan	1335	A	908	28		2150	
345	31-Jan	1350	A	908	33		2070	
346	31-Jan	1404	A	908	35		2270	
347	31-Jan	1420	A	908	29		1590	
348	31-Jan	1425	A	908	23		1570	
349	31-Jan	1430	A	908	30		1720	
350	31-Jan	1450	A	908	26		1690	
351	31-Jan	1535	A	908	26		1780	
352	31-Jan	1540	A	908	27		1870	
353	31-Jan	1545	A	908	30		1680	
354	31-Jan	1600	A	908	32		1940	
355	31-Jan	1605	A	908	29		2060	
319	31-Jan	2350	B	907	23		790	
			Average		27 5	31 0	1629	1533
			Std Dev		6 9	7 9	469	348
			No		48	9	48	10

Appendix D.7

Analytical Data on CSB from Plant E

SAMPLE					Vitamin C (mg/100g)		Vitamin A (IU/100g)		Iron (mg/100g)		Niacin (mg/100g)	
No	Day	Time	Shift	Lot	Assay	Check	Assay	Check	Assay	Check	Assay	Check
2-200	2-Apr	2000	2	28	55	68	3040	3300	24 4	25 2	7 1	7 2
2-210	2-Apr	2100	2	28	37		2610		22 8		6 7	
2-220	2-Apr	2200	2	28	47		3560		24 3		7 6	
2-230	2-Apr	2300	2	28	55		2840		21 2		6 7	
3-010	3-Apr	100	3	28	49	54	3400	3200	23 6	23 2	7 9	7 9
3-030	3-Apr	300	3	28	40		2600		19 3		6 6	
3-040	3-Apr	400	3	29	42		2490		19 1		6 3	
3-050	3-Apr	500	3	29	46		2870		22 3		6 4	
3-060	3-Apr	600	3	29	41		3280		24 8		7 5	
3-070	3-Apr	700	3	29	42		3210		23 5		7 4	
3-080	3-Apr	800	1	29	56	59	3730	3670	26 3	27 6	8 4	8 2
3-090	3-Apr	900	1	29	47	38	2770	2860	21 2	21 2	7 1	6 9
3-114	3-Apr	1140	1	29	42		2420		20 0		6 4	
3-133	3-Apr	1330	1	29	56		2790		22 8		7 6	
3-143	3-Apr	1430	1	29	75		5190		38 0		11 0	
3-180	3-Apr	1800	2	29	39	48	3470	3110	24 2	24 0	7 8	7 4
3-190	3-Apr	1900	2	29	37		2760		20 4		6 9	
3-210	3-Apr	2100	2	29	32		2630		19 2		7 1	
4-000	4-Apr	0	3	30	36	48	2810	2920	23 4	23 8	7 2	7
4-010	4-Apr	100	3	30	40		2960		23 1		7 7	
4-020	4-Apr	200	3	30	36		2360		21 1		7 2	
4-030	4-Apr	300	3	30	45		3240		23 9		7 7	
5-020	5-Apr	200	1	30	38		2400		21 2		5 6	
5-030	5-Apr	300	1	30	43	51	3770	3980	26 7	26 0	7 9	8 1
5-040	5-Apr	400	1	31	43		3350		24 6		7 8	
5-050	5-Apr	500	1	31	32		2350		20 8		5 9	
5-060	5-Apr	600	1	31	38		2790		20 4		7 3	
5-070	5-Apr	700	1	31	46		3700		25 6		8 6	
5-090	5-Apr	900	2	31	43		3040		24 0		7 5	
5-100	5-Apr	1000	2	31	34		2820		22 0		7 3	
5-110	5-Apr	1100	2	31	48		2980		25 2		7 6	
5-120	5-Apr	1200	2	31	57	55	2970	3050	22 7	23 1	7 8	7 8
5-170	5-Apr	1700	3	31	35		2470		18 8		6 7	
5-180	5-Apr	1800	3	31	48		2820		22 7		7 5	
5-190	5-Apr	1900	3	31	49		3070		23 1		8 4	
5-200	5-Apr	2000	3	31	51		2470		18 6		6 5	
5-210	5-Apr	2100	3	31	47		2910		22 5		7 4	
6-000	6-Apr	0	1	32	46		2660		20 7		7 0	
6-010	6-Apr	100	1	32	61		3170		23 8		8 2	
6-020	6-Apr	200	1	32	38	34	2450	2320	18 8	18 2	6 5	6 5
6-030	6-Apr	300	1	32	40		2400		19 3		6 5	
6-040	6-Apr	400	1	32	45		3110		23 1		7 4	
6-050	6-Apr	500	1	32	37		2510		20 1		6 8	
6-070	6-Apr	700	1	32	53		2750		21 8		7 2	
6-110	6-Apr	1100	2	32	31	33	2540	2730	19 9	21 1	6 5	7 2
6-140	6-Apr	1400	2	32	39		2230		19 8		6 3	
6-150	6-Apr	1500	2	32	38		2900		22 5		7 4	
6-160	6-Apr	1600	2	32	32		2950		22 3		7 1	
		Average			43 9	48 8	2929	3114	22 5	23 3	7 27	7 42
		Std Dev			8 6	10 6	506	446	3 1	2 6	0 84	0 53
		Number			48	10	48	10	48	10	48	10

Appendix D 7

Analytical Data on CSB from Plant H

SAMPLE DESIGNATION				Vitamin C (mg/100g)		Niacin (IU/100g)		Vitamin A (IU/100g)		Iron (mg/100g)	
No	Time	Day	Lot	Assay	Check	Assay	Check	Assay	Check	Assay	Check
1	930	19-Aug	1019	29		6 2		2560		20 8	
2	1000	19-Aug	1019	36		5 8		2390		23 7	
3	1030	19-Aug	1019	35		6 4		2210		22 3	
4	1100	19-Aug	1019	37		6 8		2480		25 2	
5	1120	19-Aug	1019	41		6 7		2070		25 4	
6	1140	19-Aug	1019	31	35	7 0	6 8	2220	2070	23 9	24 3
7	1310	19-Aug	1019	34		6 7		2150		23 5	
8	1330	19-Aug	1019	38		7 1		2590		25 2	
9	1400	19-Aug	1019	23	25	7 4	6 8	2490	2530	23 5	23 8
10	730	21-Aug	1021	50		7 4		2520		24 5	
11	750	21-Aug	1021	29		7 1		2350		25 1	
12	1000	21-Aug	1021	34	42	7 0	6 8	2370	2720	21 4	21 6
13	1010	21-Aug	1021	32		6 9		2070		20 1	
14	1040	21-Aug	1021	23		7 0		2150		24 7	
15	1050	21-Aug	1021	42		6 1		2070		21 2	
16	1140	21-Aug	1021	33		7 4		2720		24 4	
17	1150	21-Aug	1021	38	48	6 5	6 9	2240	2210	22 3	22 4
18	1300	21-Aug	1021	42		7 6		3020		25 1	
19	1340	21-Aug	1021	43	45	6 5	6 3	2320	2070	20 5	20 9
20	1450	21-Aug	1021	35		6 5		2200		20 7	
21	1510	21-Aug	1021	39		6 8		2110		20 0	
22	1530	21-Aug	1021	26		7 4		2340		21 9	
23	1550	21-Aug	1021	36		6 1		2310		22 9	
24	710	22-Aug	1022	36		6 6		2240		22 7	
25	720	22-Aug	1022	55		5 9		2110		22 9	
26	740	22-Aug	1022	31		6 3		2070		21 2	
27	800	22-Aug	1022	45		6 3		2230		23 5	
28	810	22-Aug	1022	28		6 3		2320		24 2	
29	820	22-Aug	1022	30		6 0		2450		24 0	
30	840	22-Aug	1022	48	35	6 6	6 3	2380	2170	25 1	24 7
31	930	22-Aug	1022	27		6 1		2520		27 2	
32	940	22-Aug	1022	46		6 8		2030		25 8	
33	1000	22-Aug	1022	43		6 2		2120		25 9	
34	1020	22-Aug	1022	45		6 6		2220		27 5	
35	1030	22-Aug	1022	31		5 9		2090		24 5	
36	1110	22-Aug	1022	57		6 7		2470		26 3	
37	1120	22-Aug	1022	36		6 3		2500		25 6	
38	1140	22-Aug	1022	43		6 2		3010		25 0	
39	1300	22-Aug	1022	33		6 9		2890		24 9	
40	1340	22-Aug	1022	58		7 9		3200		25 3	
		Average		37 5	38 3	6 65	6 65	2370	2295	23 75	22 95
		Std Dev		8 5	7 7	0 50	0 25	279	245	1 94	1 41
		Number		40	6	40	6	40	6	40	6

Appendix D 7

Analytical Data on Wheat Flour from Plant F

SAMPLE			Vitamin A (IU/100g)		Iron (mg/100g)	
No	Time	Date	Assay	Check	Assay	Check
1	740	17-Jul	1530		6 3	
2	750	17-Jul	1410		5 1	
3	800	17-Jul	1560		6 4	
4	810	17-Jul	1590		6 3	
5	820	17-Jul	1510		6 0	
6	930	21-Jul	2060		6 6	
7	1030	21-Jul	1310		8 4	
8	1130	21-Jul	1410		6 3	
9	1230	21-Jul	1570		5 6	
10	1330	21-Jul	1540		4 4	
11	1430	21-Jul	1400		4 5	
12	1100	23-Jul	750		6 0	
13	1200	23-Jul	940		4 8	
14	1300	23-Jul	1120		4 0	
15	1400	23-Jul	1750		5 4	
16	1500	23-Jul	1980		5 1	
17	1000	24-Jul	1720		5 0	
18	1100	24-Jul	2050		5 6	
19	1200	24-Jul	770	710	2 6	2 6
20	1300	24-Jul	1530		6 8	
21	800	28-Jul	1420		4 2	
22	900	28-Jul	800		3 0	
23	1000	28-Jul	1340		4 3	
24	1100	28-Jul	1540		4 8	
25	1200	28-Jul	1150		4 4	
26	1400	28-Jul	950		4 4	
27	1000	30-Jul	1020		4 6	
28	1100	30-Jul	910		4 0	
29	1200	30-Jul	1220		4 2	
		Average	1374		5 14	
		Std Dev	359		1 20	
		Number	29		29	

Appendix D 7

Analytical Data on Corn Meal from Plant C

SAMPLE						**Vitamin A (IU/100g)**		**Iron (mg/100g)**	
No	Day	Time	Line	Lot	Bag No	Assay	Check	Assay	Check
1	8-Oct	710	A	BL	185	2990		4 9	
2	8-Oct	735	B	BL	615	3230		5 2	
3	8-Oct	700	B	BL	150	3300		4 7	
4	8-Oct	740	A	BL	743	2950		4 4	
5	8-Oct	830	B	BL	1547	3110		4 6	
6	8-Oct	900	B	BL	2000	3010		4 8	
7	8-Oct	835	A	BL	1606	2860		4 3	
8	8-Oct	955	B	BL	2650	3040		4 8	
9	8-Oct	905	A	BL	2114	3040		4 8	
10	8-Oct	1000	A	BM	1000	3290		5 1	
11	8-Oct	1050	B	BM	880	3190	3250	5 1	4 8
12	8-Oct	1030	B	BM	505	2920		4 2	
13	8-Oct	1035	A	BM	1035	2940		5 1	
14	8-Oct	1100	A	BM	1100	2740		5 3	
15	8-Oct	1120	B	BM	1330	3080		5 0	
16	8-Oct	1125	A	BM	1505	3040		6 3	
17	8-Oct	1220	B	BM	2065	3050		5 6	
19	8-Oct	1230	B	BM	1225	3160	3360	6 3	4 9
20	8-Oct	1240	A	BM	2360	3240		5 9	
21	8-Oct	1250	B	BM	2240	3270		5 2	
22	8-Oct	1300	A	BM	2547	3170	2770	4 8	5 2
24	8-Oct	1310	B	BM	2570	3100	3060	4 8	4 8
28	10-Oct	655	B	BN	5	2220		7 6	
29	10-Oct	705	A	BN	115	3060		5 6	
30	10-Oct	720	B	BN	280	2710		5 6	
31	10-Oct	740	A	BN	800	2990	3120	5 6	5 6
33	10-Oct	800	B	BN	965	3320		4 4	
34	10-Oct	810	A	BN	1220	3330	3030	6 0	5 6
36	10-Oct	835	B	BN	1670	3010		4 8	
37	10-Oct	850	A	AA	30	2820		5 6	
38	10-Oct	910	B	AA	430	2670		5 2	
39	10-Oct	925	A	AA	580	3160		6 0	
40	17-Oct	805	B	AL	1150	3340		4 2	
41	17-Oct	820	A	AL	1370	3070		4 8	
42	17-Oct	840	B	AL	1800	3220	3200	5 6	5 6
44	17-Oct	855	A	AL	1970	3260		5 6	
45	17-Oct	915	B	AL	2360	2950		5 8	
46	17-Oct	925	A	AL	2620	2800	2830	5 4	5 4
48	17-Oct	1000	B	AM	235	2890		5 8	
49	17-Oct	1010	A	AM	350	3430		5 4	
50	17-Oct	1020	B	AM	500	2790	2920	5 6	5 8
52	17-Oct	1030	A	AM	650	2950		5 2	
53	17-Oct	1040	B	AM	915	3210		5 0	
54	17-Oct	1050	A	AM	1030	3140	3110	6 0	5 4
55	17-Oct	1100	B	AM	1100	2820		4 8	
56	17-Oct	1110	A	AM	1420	3000		5 6	
57	17-Oct	1125	B	AM	1610	2870		4 4	
59	17-Oct	1045	B	AM	800	3070		4 8	
				Average		3 038	3 065	5 24	5 31
				Std Dev		216	176	0 64	0 35
				Number		48	10	48	10

Appendix D 7

Analytical Data on Soy Fortified Bulgur from Plant G

SAMPLE				Vitamin A (IU/100g)				Iron (mg/100g)				Moisture
No	Time	Date	Lot	Assay	Check	b	c	Assay	Check	b	c	%
1	940	19-Aug	1002	1330	1320			6 4	6 9			11 2
2	1000	19-Aug	1002	980				6 0				
3	1100	19-Aug	1002	1410		1710	1820	5 6		6 8	5 5	
4	1120	19-Aug	1002	1610				5 3				
5	1320	19-Aug	1002	1370				6 4				
6	1340	19-Aug	1002	1070	1130	1460		5 8	6 3	6 4		10 9
7	1420	19-Aug	1002	1250				5 5				
8	730	20-Aug	1005	1150				4 9				
9	740	20-Aug	1005	1110		1500	1440	4 9		5 8	5 0	11 1
10	830	20-Aug	1005	1610				5 2				
11	840	20-Aug	1005	1570				5 0				
12	900	20-Aug	1005	1410				4 9				
13	950	20-Aug	1005	1150		1660	1680	5 8		5 8	5 2	
14	1000	20-Aug	1005	1260				5 4				
15	1030	20-Aug	1005	1820		1530	1800	6 0		5 2	6 2	11 2
16	1100	20-Aug	1005	2420		2550	2470	6 4		6 6	6 7	
17	1130	20-Aug	1005	1340				5 5				
18	1300	20-Aug	1005	1500		1720	1790	5 1		4 9	5 7	
19	1330	20-Aug	1005	1110				5 4				
20	1400	20-Aug	1004	1110	1030	1680	1700	5 8	5 5	6 6	5 7	11 0
21	1440	20-Aug	1004	1480		1470	2010	5 2		4 9	5 8	
22	1500	20-Aug	1004	1480	1200			5 2	5 7			10 7
23	1840	20-Aug	1006	1020				5 1				
24	1940	20-Aug	1006	1180				6 0				
25	2110	20-Aug	1006	1260				5 8				
26	720	21-Aug	1007	770	780			5 9	5 5			11 2
27	740	21-Aug	1007	990				5 7				
28	910	21-Aug	1007	1600		1970	2980	6 2		6 9	6 9	
29	1010	21-Aug	1007	2220				6 1				
30	1030	21-Aug	1007	1000		1520	1780	6 1		5 3	5 8	11 1
31	1130	21-Aug	1007	1790				5 7				
32	1300	21-Aug	1007	1410				5 6				
33	1340	21-Aug	1007	2210				6 5				
34	1510	21-Aug	1007			1790	2930			6 4	6 5	
35	1030	22-Aug	1009	1610	1580			5 3	4 7			11 0
36	1140	22-Aug	1009	1380	1380			5 3	5 3			10 0
37	1300	22-Aug	1009	1570				5 2				
38	1340	22-Aug	1009	1830				5 5				
39	1400	22-Aug	1009	1860				6 1				
40	1430	22-Aug	1009	2340				6 5				
	Average			1451	1203	1713	2036	5 65	5 70	5 97	5 91	10 94
	Std Dev			385	239	291	496	0 47	0 66	0 71	0 58	0 35
	Number			39	7	12	11	39	7	12	11	10

Appendix D 7

Vitamin A in Bulgur Trials at Plant G

Study run February 24th and 25th, 1998
Five runs of fortified bulgur were run at plant G with two different kinds of vitamin premixes added at different addition rates

The top two sets (11-26) were made with conventional powered vitamin/iron premix
The bottom three sets (31-55) were made with a sticky/granulated vitamin/iron premix using wheat germ as the carrier
Vitamin A results are from Lancaster Labs

	Vitamin A (IU/100g)			% of	% of
Sample Designation	Assay	Bag mean	Added	minimum	added
11 Bulgur (Top Of Packer)	1870				
12 Bulgur (Bagger)	6470				
13 Bulgur (A)	2010				
14 Bulgur (B)	2960				
15 Bulgur (C)	2870	2613	3308	119%	79%
21 Bulgur (Top Of Packer)	1490				
22 Bulgur (Packer)	3510				
23 Bulgur (A)	2930				
24 Bulgur (B)	3050				
25 Bulgur (C)	3550	3177	3308	144%	96%
31 Bulgur (Top of Packer)	2590				
32 Bulgur (Packer)	3270				
33 Bulgur (A)	2170				
34 Bulgur (B)	2650				
35 Bulgur (C)	3040	2620	2426	119%	108%
41 Bulgur (Top Of Packer)	4260				
42 Bulgur (Packer)	3600				
43 Bulgur (A)	3070				
44 Bulgur (B)	4370				
45 Bulgur (C)	4100	3847	3087	175%	125%
51 Bulgur (Top of Packer)	3500				
52 Bulgur (Packer)	3650				
53 Bulgur (A)	2990				
54 Bulgur (B)	5630				
55 Bulgur (C)	4380	4333	3749	197%	116%

KEY

Sample Designation or location where sample was taken
(Top of Packer) is the middle of the bin that feeds into packer directly under the conveyor
(Packer) is a sample taken lengthwise through a bag with sampling probe directly after the bag was filled and not yet sealed
(A) is a sample taken widthwise through the top third of a bag taken from the conveyor belt
(B) is a sample taken widthwise through the middle third of that bag taken from the conveyor belt
(C) is a sample taken widthwise through the bottom third of that bag taken from the conveyor belt

Bag mean is the average content in the bag or the average of the last three values
Added is the theoretical amount of vitamin A added based on the vitamin A content in the premix and the set addition rate
Percent of Minimum is the bag mean as a percentage of the minimum, or 2202 IU/100g
Percent of Added is the bag mean as a percentage of the theoretical amount added

Appendix D 8
Announcement on Addition of Vitamin A to Vegetable Oil

NOTICE TO THE TRADE

At the request of the U S Agency of International Development, Office of Food for Peace, the Kansas City Commodity Office will amend the Announcement VO-6 to require vitamin A fortification (in the form of retinol palmitate) to vegetable oil purchased for foreign food assistance programs, unless specified otherwise in an invitation It is estimated that Title II vegetable oil reaches approximately 20 million recipients in over 40 developing countries In nutrient deficient populations, vitamin A not only prevents blindness, but it increases child survival rate by an average of 23 percent A specially-commissioned report has determined that vitamin A fortification is safe, effective and economical

We are amending Announcement VO-6, "Purchase of Vegetable Oil for Use in Export Programs," to reflect the recommended fortification level of 60-75 IU/g for all contracts, unless otherwise specified by the cooperating sponsor, after December 1, 1998 Vitamin A should be in the form of retinol palmitate This will provide vendors time to comply with the request for the addition of fortification Also, we are amending labeling requirements to require the following statement, "Vegetable Oil, Vitamin A Fortified" to be imprinted on the containers

All vegetable oil offered must be produced and packed under sanitary conditions and must conform in every respect to the provisions of the "Federal Food, Drug, and Cosmetic Act," as amended, and the regulations promulgated thereunder Vendors should have sufficient quality control measures to ensure the proper addition of the vitamin A (retinol palmitate) and homogeneity in the vegetable oil Inspection, as required by USDA-1, will be performed by the Federal Grain Inspection Service (FGIS), GIPSA However, to expedite shipments and reduce Government testing, contractors are authorized to utilize the services of a private, independently owned and operated laboratory capable of performed the analytical test for vitamin A content in oil Samples will be selected randomly by FGIS representatives Analytical results obtained by the designated laboratory must be submitted to the FGIS representative on stationary bearing the laboratory's letterhead If a contractor chooses to utilize the services of a private, independently owned and operated laboratory, Commodity Credit Corporation reserves the right to ensure the validity of the independent laboratory's results through random and unannounced comparison testing using samples randomly submitted to USDA Commodity Testing Laboratories by FGIS representatives

APPENDIX E
Production Plant Data

Appendix E

Explanation for Summary Tables

These tables summarize the results from the different plants for each nutrient tested The first section provides data on the fortification including the mean level and the mean as a percentage of the target level added In some cases outliers were removed if they differed excessively from the mean

The second section of each table shows the variation of the micronutrient The lower the Coefficient of Variation (COV), the better the uniformity The ten blind duplicates taken at each production run allow calculation of the proportion of the variability due to analytical error, the remainder being due to production This indicates to what extent a uniformity problem is the result of high analytical error In some cases, such as wheat flour from Plant F, there were insufficient replicates (shown by I/D) to calculate analytical error The "adjusted COV" shown on each table is the COV corrected for analytical error It is calculated by multiplying the COV by the proportion of the variability due to production An adjusted COV below 10% indicates a good or acceptable level of uniformity In no case did the adjusted COV provide a different picture of plant uniformity from that provided by the standard COV, meaning that analytical error did not greatly alter the results

The "Process Capability" section provides indices on how well the plant did in meeting current or proposed micronutrient standards The minimum and maximum levels shown for CSB and WSB are based on the ones proposed by SUSTAIN and USAID to the USDA The vitamin C levels are based on suggestions from Plant C personnel They are used here only to be able to calculate the process capability values shown in the tables The standard values shown for the other commodities are actual specifications currently in effect Because of the high natural levels of niacin and iron in CSB and WSB, process capability calculations for these commodities would not be meaningful (indicated by N/A in the tables)

The process capability (Cp) is the ratio of the Upper Control Limit (UCL) less the Lower Control Limit (LCL) to the maximum–minimum specification Ideally, the Cp should be above 1 0, meaning that specified range could be achieved 99% of the time For low Cps, as in these cases, the Cpk is more meaningful The Cpk is the minimum distance between a specification (upper or lower) and the production mean, relative to the range in the data from the mean to either extreme The Cpk is a truer index of how well the plant did in meeting specifications because it eliminates the bias of being high or low Again, a value above 1 0 is ideal, but not truly attainable in this situation Also calculated is the percentage of the production that would be expected to fall below the minimum specification and above the maximum specification, assuming a normal distribution

Appendix E

Summary of Vitamin A Results from Production Plants

Plant	B	C	C	D	E	F	G	H
Product	WSB	CM	CSB	CSB	CSB	WF	SFB	CSB
Target (IU/100g)	2315	2205	2315	2315	2315	2205	2205	2315
Number of samples	44	48	47	48	47	29	39	40
Minimum (IU/100g)	2340	2220	1670	260	2230	750	770	2030
Maximum (IU/100g)	3790	3430	2660	2710	3770	2060	2420	3200
Average content (IU/100g)	2954	3038	2110	1620	2881	1374	1451	2370
Mean as percent of target	128	138	91	70	124	57	60	102
Uniformity								
Standard Deviation (IU/100g)	306	216	227	479	387	389	385	279
Coefficient of Variation (%)	10	7	11	30	13	26	27	12
Lower Control Limit (IU/100g)	2036	2391	1430	184	1719	297	296	1533
Upper Control Limit (IU/100g)	3871	3685	2790	3057	4043	2451	2606	3207
Variability								
Due to production (%)	61		51	67	92	I/D	91	46
Due to analysis (%)	39		49	33	8	I/D	9	54
COV adjusted for analytical error (%)	6		6	20	12	I/D	25	6
Process Capability								
Minimum level * (IU/100g)	1850	2205	1850	1850	1850	2205	2205	1850
Maximum level * (IU/100g)	3240	2646	3240	3240	3240	2646	2646	3240
Process capability (Cp)	0 76	0 34	1 04	0 48	0 60	0 20	0 19	0 83
Process capability index (Cpk)	0 14	<0	0 17	<0	0 21	<0	<0	0 34
Percent falling below minimum (%)	0	0	13	69	0	99	98	3
Percent falling above maximum (%)	18	97	0	0	18	0	0	0
Percent outside specifications (%)	18	97	13	69	18	99	98	3

* Proposed range for CSB and WSB   Other values are current specifications

N/A = Not Applicable, I/D = Insufficient Data

Appendix E
Summary of Vitamin C Results from Production Plants

Plant	A	B	C	D	E	H
Product	CSB	WSB	CSB	CSB	CSB	CSB
Target (mg/100g)	40	40	40	40	40	40
Number of samples	43	42	47	48	47	40
Number of outliers removed	1	0	0	0	1	0
Minimum (mg/100g)	1	32	25	7	31	23
Maximum (mg/100g)	72	53	52	39	61	58
Average content (mg/100g)	27 0	42 7	37 0	27 4	43 2	37 5
Mean as percent of target	82	107	93	69	108	94
Uniformity						
Standard Deviation (mg/100g)	16 4	4 7	6 3	6 8	7 4	8 5
Coefficient of Variation (%)	61	11	17	25	17	23
Lower Control Limit (mg/100g)	0	29	18	7	21	12
Upper Control Limit (mg/100g)	160	57	56	48	65	63
Variability						
Due to production (%)	97	48	93	70	72	59
Due to analysis (%)	3	52	7	30	28	41
COV adjusted for analytical error (%)	59	5	16	18	12	14
Process Capability						
Minimum level* (mg/100g)	24	24	24	24	24	24
Maximum level* (mg/100g)	56	56	56	56	56	56
Process capability (Cp)	0 32	1 12	0 83	0 78	0 73	0 63
Process capability index (Cpk)	<0	0 47	0 72	0 50	0 60	1 13
Percent falling below minimum (%)	43	0	2	31	1	6
Percent falling above maximum (%)	4	0	0	0	4	2
Percent outside specifications (%)	47	0	2	31	5	7

* Hypothetical range based on target ±40%

Appendix E
Summary of Iron Results from Production Plants

Plant	C	C	E	F	G	H
Product	CM	CSB	CSB	WF	SFB	CSB
Target (mg/100g)	4 3	14 7	14 7	4 4	2 9	14 7
Number of samples	48	46	47	29	39	40
Minimum (mg/100g)	4 2	10 7	18 6	2 6	4 9	20 0
Maximum (mg/100g)	7 6	30 9	26 7	8 4	6 5	27 5
Average content (mg/100g)	5 2	20 2	22 2	5 1	5 7	23 8
Mean as percent of target	122	137	151	117	128	102
Uniformity						
Standard Deviation (mg/100g)	0 64	4 57	2 10	1 20	0 47	1 94
Coefficient of Variation (%)	12	23	9	23	8	8
Lower Control Limit (mg/100g)	3 3	6 4	15 9	1 5	4 2	17 9
Upper Control Limit (mg/100g)	7 2	33 9	28 5	8 7	7 1	29 6
Variability						
Due to production (%)		90	98	I/D	71	96
Due to analysis (%)		10	2	I/D	29	4
COV adjusted for analytical error (%)		21	9		6	8
Process Capability						
Minimum specification (mg/100g)	2 9	N/A	N/A	4 4	2 9	N/A
Maximum specification (mg/100g)	5 7	N/A	N/A	none	5 7	N/A
Process capability (Cp)	0 73	N/A	N/A	N/A	1 0	N/A
Process capability index (Cpk)	0 14	N/A	N/A	N/A	0	N/A
Percent falling below minimum (%)	0	N/A	N/A	27	0	N/A
Percent falling above maximum (%)	24	N/A	N/A	N/A	46	N/A
Percent outside specifications (%)	24	N/A	N/A	27	46	N/A

N/A = Not Applicable, I/D = Insufficient Data

Appendix E
Summary of Niacin Results from Production Plants

Plant	B	C	E	H
Product	WSB	CSB	CSB	CSB
Target (mg/100g)	4 96	4 96	4 96	4 96
Number of samples	44	47	47	40
Minimum (mg/100g)	8 9	5 7	5 6	5 8
Maximum (mg/100g)	11 0	7 0	8 6	7 9
Average content (mg/100g)	9 7	6 4	7 2	6 7
Mean as percent of target	195	128	145	134
Uniformity				
Standard Deviation (mg/100g)	0 44	0 35	0 65	0 50
Coefficient of Variation (%)	4 5	5 5	9 0	7 6
Lower Control Limit (mg/100g)	8 3	5 3	5 2	5 1
Upper Control Limit (mg/100g)	11 0	7 4	9 1	8 2
Variability				
Due to production (%)	58	53	89	45
Due to analysis (%)	42	47	11	55
COV adjusted for analytical error (%)	3	3	8	3

N/A = Not Applicable, I/D = Insufficient Data

Appendix E
Plant and Process Descriptions

Production plants are designated only by an alphabetical letter in order to maintain the confidentiality of the companies involved Each letter indicates a production facility for a particular commodity In some cases two of the sampled commodities were being made at the same location In plant C both corn meal and CSB were made on the same equipment Flow diagrams for each plant are provided in this Appendix

Plant A

This plant produces corn soy blend and corn meal The vitamins and minerals were added by two small feeders within view of the person running the packer One feeder fed the mineral premix and one fed the vitamin premix The fortified product ran through a short mixer and then was blown out to the packing room An auger carried the product from the bottom of a cyclone separator to the holding bin over the packer A switch on this bin would automatically shut down the whole system, including the nutrient feeders, if this holding bin overfilled The system would also shut down automatically if the corn or soy ran out The person running the bagger could shut down the system if packaging problems developed, if he went on a break, or during shift changes (the plant ran two shifts) Bags were filled heat sealed, and conveyed to the railcars, where they were manually stacked It took three to four hours to fill a railcar with 2,500 bags A lot was two railcars, or 135 MT

Plant B

This is a large flour mill that produces WSB on a dedicated batch system The ground bulgur, soy flour, and wheat protein concentrate used to make up this product were kept in separate bins The mixer operator used a load cell scale to weigh each ingredient sequentially into one of two ribbon blenders Oil, a scoop of vitamin premix (the scoop was calibrated to provide one pound of vitamin premix), and a bag of mineral premix were added, resulting in a total mixing weight of 2,005 lbs This was then mixed three to four minutes and sent pneumatically to a 20,000 lb holding bin From there it was packed out on a single line operating during only one shift

Plant C

This grain processing plant produces CSB and exports corn meal products for the P L 480 program on the same continuous blending system specifically designed for CSB production Other degerminated corn meals manufactured at this location are sold commercially in the United States Samples of CSB and corn meal were taken during two consecutive weeks of sampling

All dry ingredients were monitored and metered into a continuous blending system that utilized a large diameter extended mixing conveyor Three screw-type micro-ingredient feeders with large capacity hoppers metered the vitamin premix, salt/mineral premix, and the tricalcium phosphate into the mixing conveyor at the same time with the precooked corn meal and soy flour ingredients for blending The refined soy oil with the antioxidants was atomized into the conveyor following the addition of these dry ingredients The blending system was designed with an interlocking scheme of equipment, so if any of the ingredient feeders stop, the blending system will automatically shut down

An industrial programmable logic controller (PLC) computer operated this continuous blending system A primary scale controlled the addition of the precooked corn meal or regular corn meal which was set within a desired range The secondary scales and feeders for the remaining ingredients were automatically adjusted by the load on the primary scale Random rate checks were taken during the blending operation for all ingredients to confirm the addition rates versus the scale readings and product specifications

The product was transferred pneumatically from the end of the mixing conveyor up several floors to a screw conveyor that transferred the blended product into six storage bins A panel located on the packing floor controlled the discharge feeders from these bins Two bins were operated at the same time and the product was conveyed pneumatically to a holding bin located above the packing stations The holding bin above the packers remained filled by an electronic control mechanism that signals the feeders to stop and start to maintain a desired level There are two packing lines that transfer bagged product to separate railcars

There are normally 2,722 bags per railcar and two cars per lot, or a total of 136 4 MT per lot Plant C normally packs out two lots per day Each bag is printed with a lot number followed by a consecutive bag number from 1 to 2,722

Plant D

This is a large corn mill that produces corn soy blend, corn meal, and masa flour for P L 480 They also produce a number of commercial products This plant works continuously 24 hours a day Most of the CSB is packed out on line A from 8 a m to 5 p m , but some CSB is packed out on line B during other times of the day

The vitamin and mineral premixes were metered screw-type feeders on the ground, which extrude corn on a screw conveyor The corn was then dropped into a "drag belt" device in which the soy flour and tricalcium phosphate is added From there, just after the oil was added the product dropped down into an intensive mixer The product was then blown up to a holding bin from which it was packed out The plant had the ability to check weight and adjust the vitamin and mineral premixes, the TCP, the soy/TCP, and the oil

Plant E

This is a small, privately owned plant producing mainly CSB with a small amount of corn meal The plant started operating in March 1994 It went out of business and was shut down for over a year and started up again in 1997 under new ownership and management New equipment was installed to fortify the product with vitamin and minerals

The pregelatinized corn meal (PCM) rate out of the bin was set using check weight (average of four 15-second weights) run each day The soy flour rate was adjusted based on final product protein, which was tested every 15 minutes These two ingredients were blown from outside bins to be mixed with the other ingredients This plant is unique in how they added the vitamins and minerals The first batch mixed tricalcium phosphate (one 2,000 lb tote bag), minerals (one 700 lb tote bag of salt mix containing salt, ferrous fumarate, and zinc sulfate), and two 50 lb boxes of vitamin premix in a ribbon blender This mix was blown over to one of three holding bins, on the bottom of which were gravimetric belt feeders over an auger Weight checks were run on each belt feeder The belt feeders had load cells that show on the monitor of a central controller what each one is delivering At the end of the auger, the vitamin/mineral mix was combined with the corn meal, soy flour, and oil and mixed in an intensive continuous mixer From there the final product was elevated with buckets to the hopper over the packer and packed out Each lot was three railcars (either 50-foot cars carrying 2,700 bags or 60-foot cars holding 3,000 bags) One lot can run from 202 MT to 225 MT

Plant F

Plant F is a conventional flour mill producing wheat flour for both commercial and government use Flour that conformed to appropriate government standards was produced and stored in a bin for packout during the day The flour was transferred through a conveyor from the bin A combination vitamin and iron premix was added to the flour in the conveyor using a standard enrichment feeder The composition of the premix is shown in table x Calcium carbonate was also added to the flour in the conveyor A bucket elevator transported the flour from the conveyor to a rebolt sifter From there it went to an entolator, which breaks up lumps, and then to a packout bin Sampling occurred over a three-week period, with samples taken from the top of the bag just after filling Samples were collected every hour over an eight-hour shift Unfortunately, a number of the samples were lost during shipping

Plant G

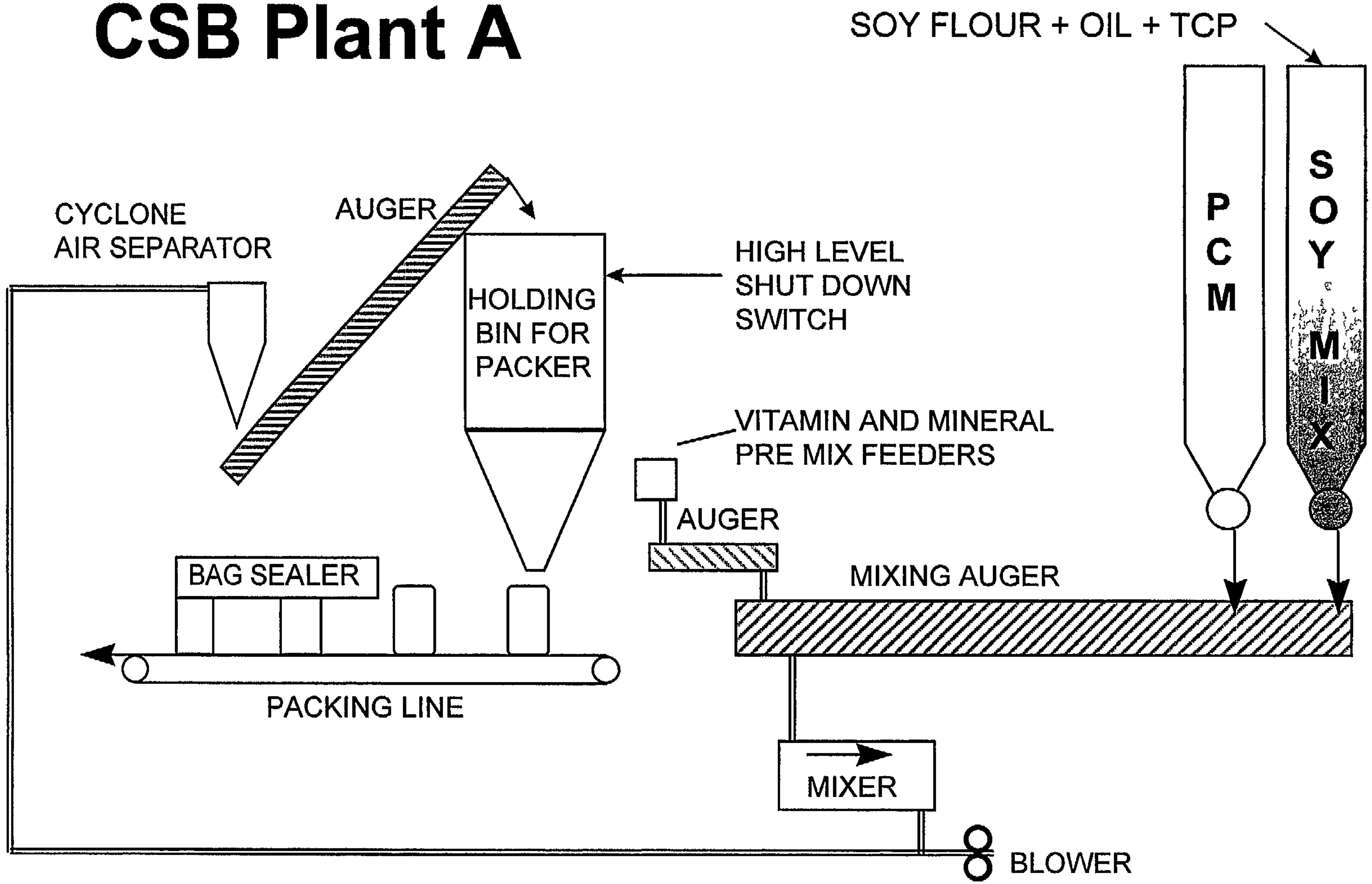
Plant G produces bulgur and soy fortified bulgur The process for making bulgur at plant G consisted of first cleaning the wheat, adding water and storing to reach a certain moisture level (tempering), cooking the tempered wheat under pressure, heating the cooked wheat followed by drying, dehulling, sizing, cooling and sifting Calcium carbonate was then metered into the product as it was transferred to the final storage bin From that bin the calcium fortified bulgur was moved through a conveyor where defatted soy flour was added (in the case of soy fortified bulgur) This conveyor led directly into a ten-foot, cut-flight mixing conveyor

The vitamin premix was dumped into a hopper and blown up to a holding bin from where it was metered into a pneumatic line that blew it into the product at the start of the mixing conveyor The product then dropped into a packout bin There was aspiration at the top of the bin and at packout to lessen the amount of dust the workers in the packaging area would be exposed to The product was packaged in 25 kg jute bags that were sewn closed It took about three minutes for the product to move from the end of the mixing conveyor to the final package From there the bags are loaded directly into railcars

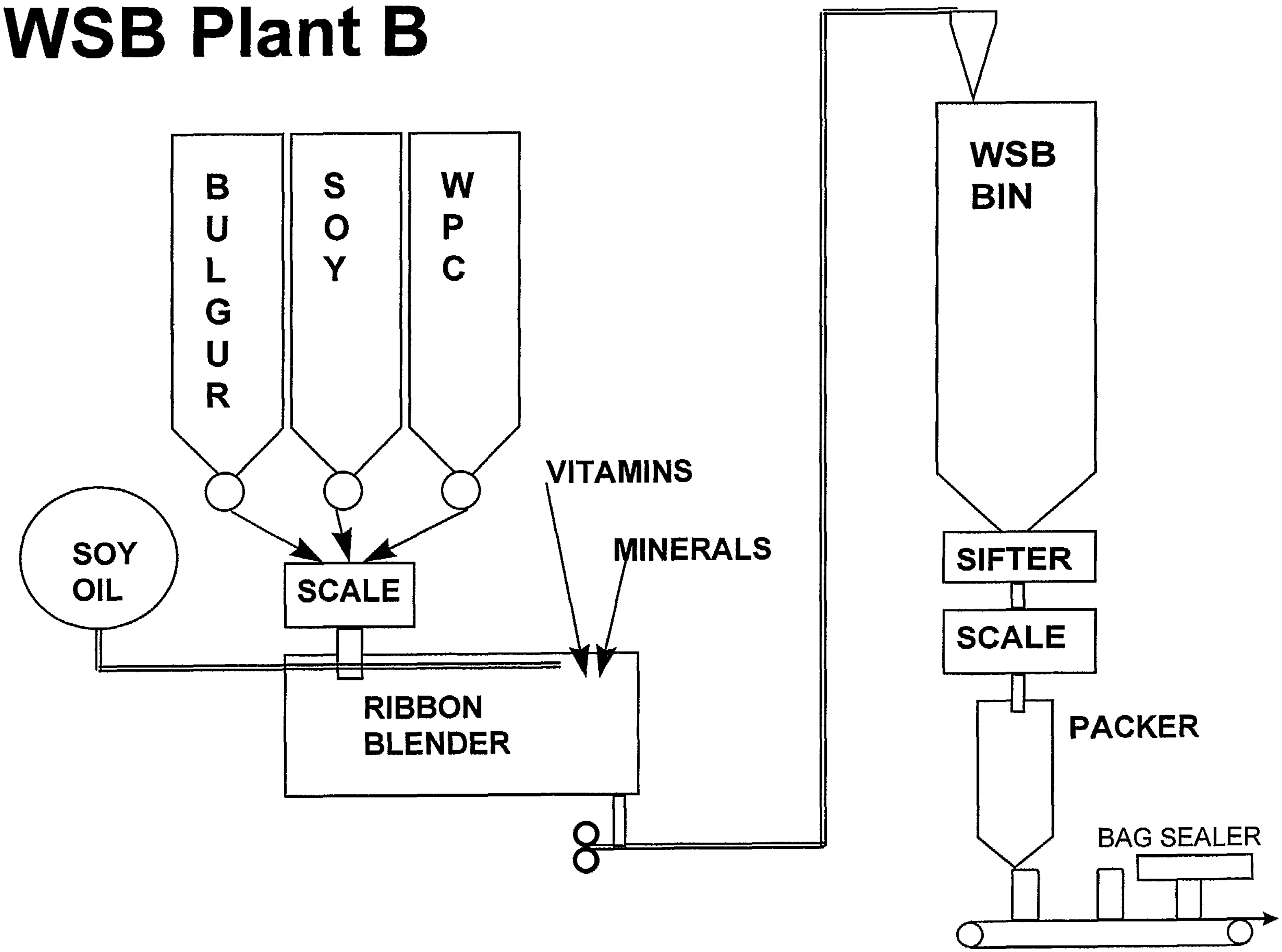
Plant H

Plant H produces CSB by combining all ingredients in two drag lines, which provide little mixing The CSB is pneumatically conveyed out of the drag lines to holding bins and from there to a high intensity mixer at which point the oil is added From there it is sent to one of two packout bins

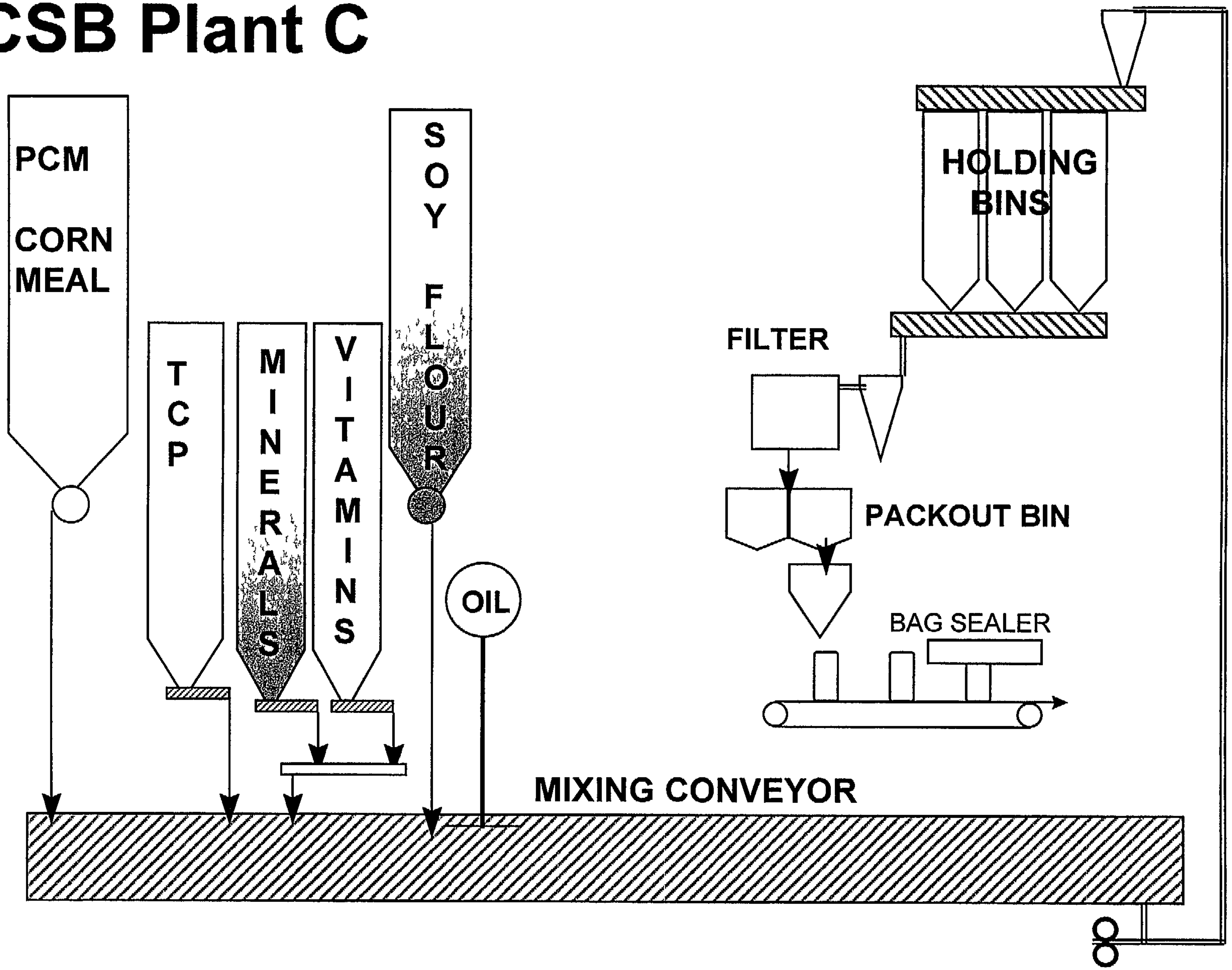
CSB Plant A


SOY FLOUR + OIL + TCP
CYCLONE
AIR SEPARATOR
AUGER
HOLDING
BIN FOR
PACKER
HIGH LEVEL
SHUT DOWN
SWITCH
PCM
SOY
MIX
VITAMIN AND MINERAL
PRE MIX FEEDERS
AUGER
BAG SEALER
MIXING AUGER
PACKING LINE
MIXER
BLOWER

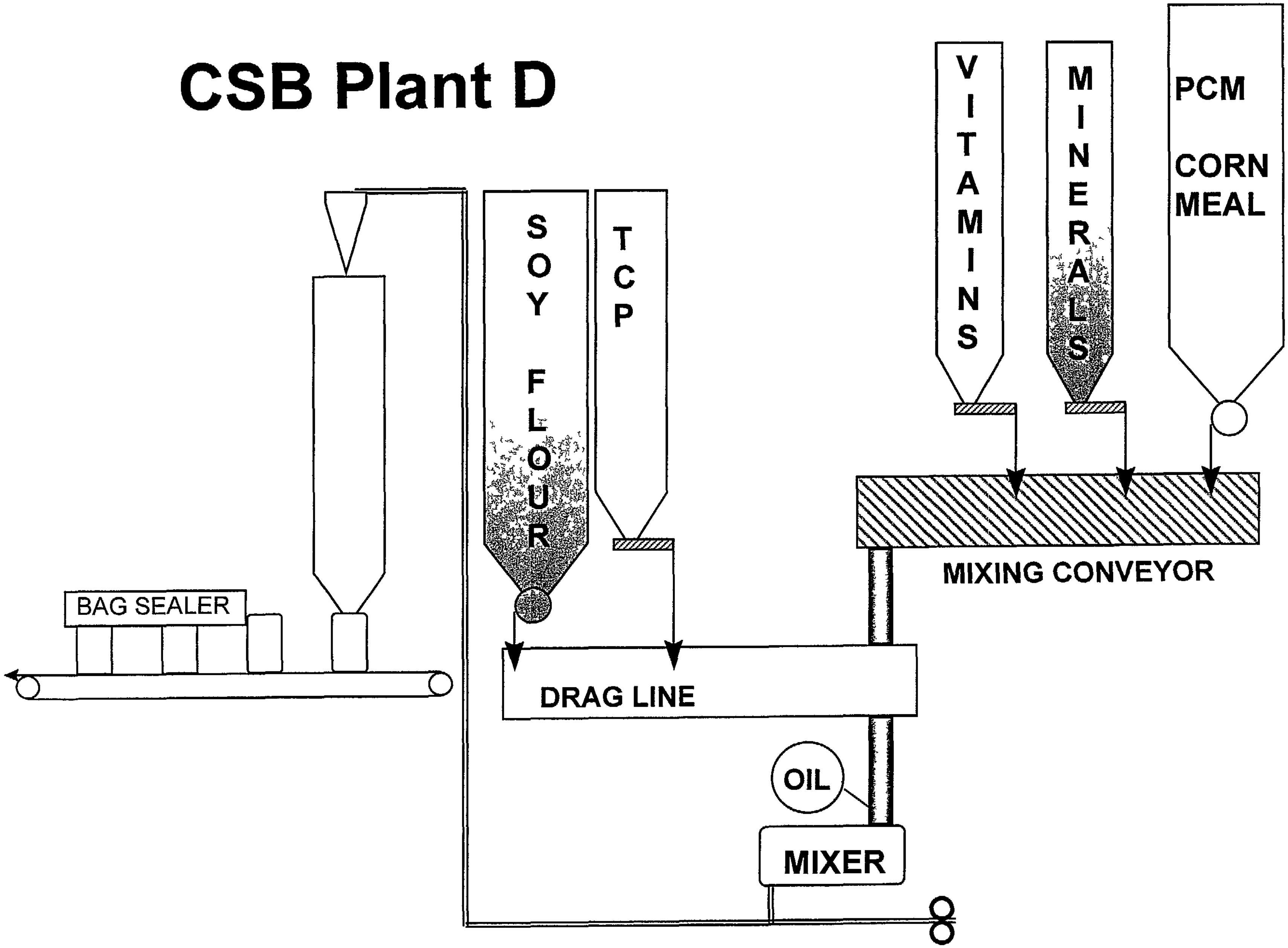
WSB Plant B


BULGUR
SOY
WPC
WSB BIN
VITAMINS
MINERALS
SOY OIL
SCALE
SIFTER
SCALE
RIBBON BLENDER
PACKER
BAG SEALER

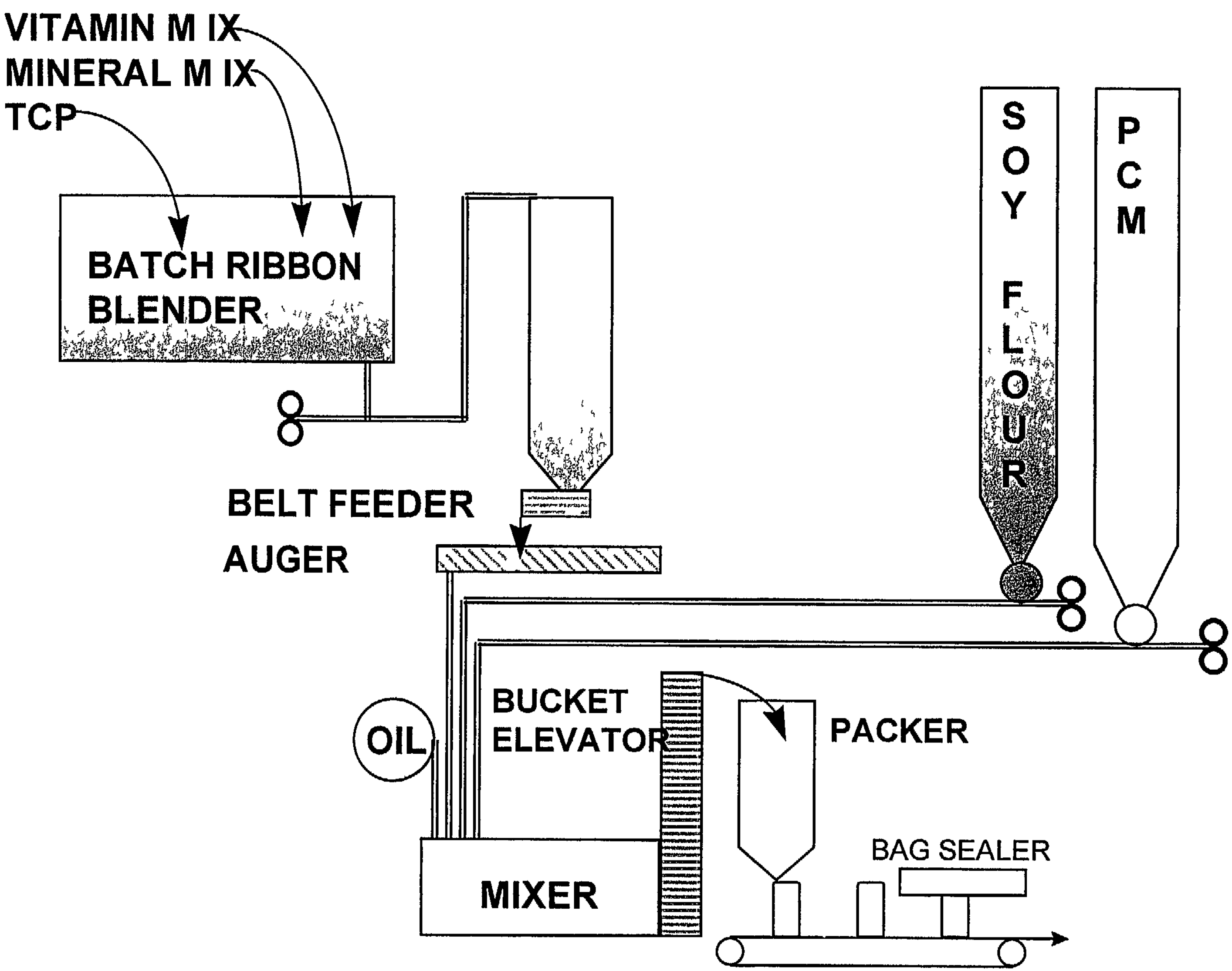
CSB Plant C


PCM
CORN MEAL
TCP
MINERALS
VITAMINS
SOY FLOUR
OIL
MIXING CONVEYOR
HOLDING BINS
FILTER
PACKOUT BIN
BAG SEALER

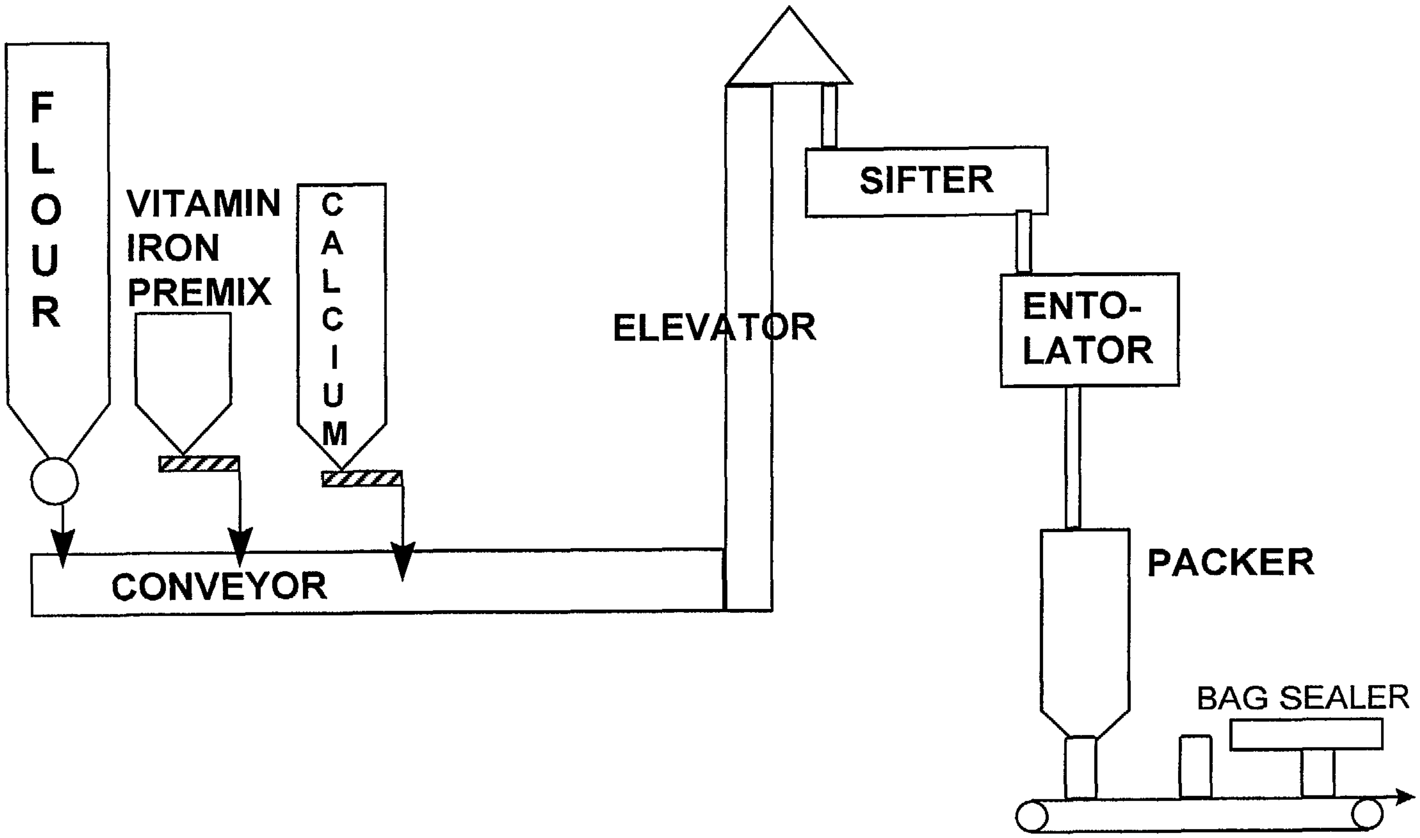
CSB Plant D


VITAMINS
MINERALS
PCM
CORN MEAL
SOY FLOUR
TCP
MIXING CONVEYOR
BAG SEALER
DRAG LINE
OIL
MIXER

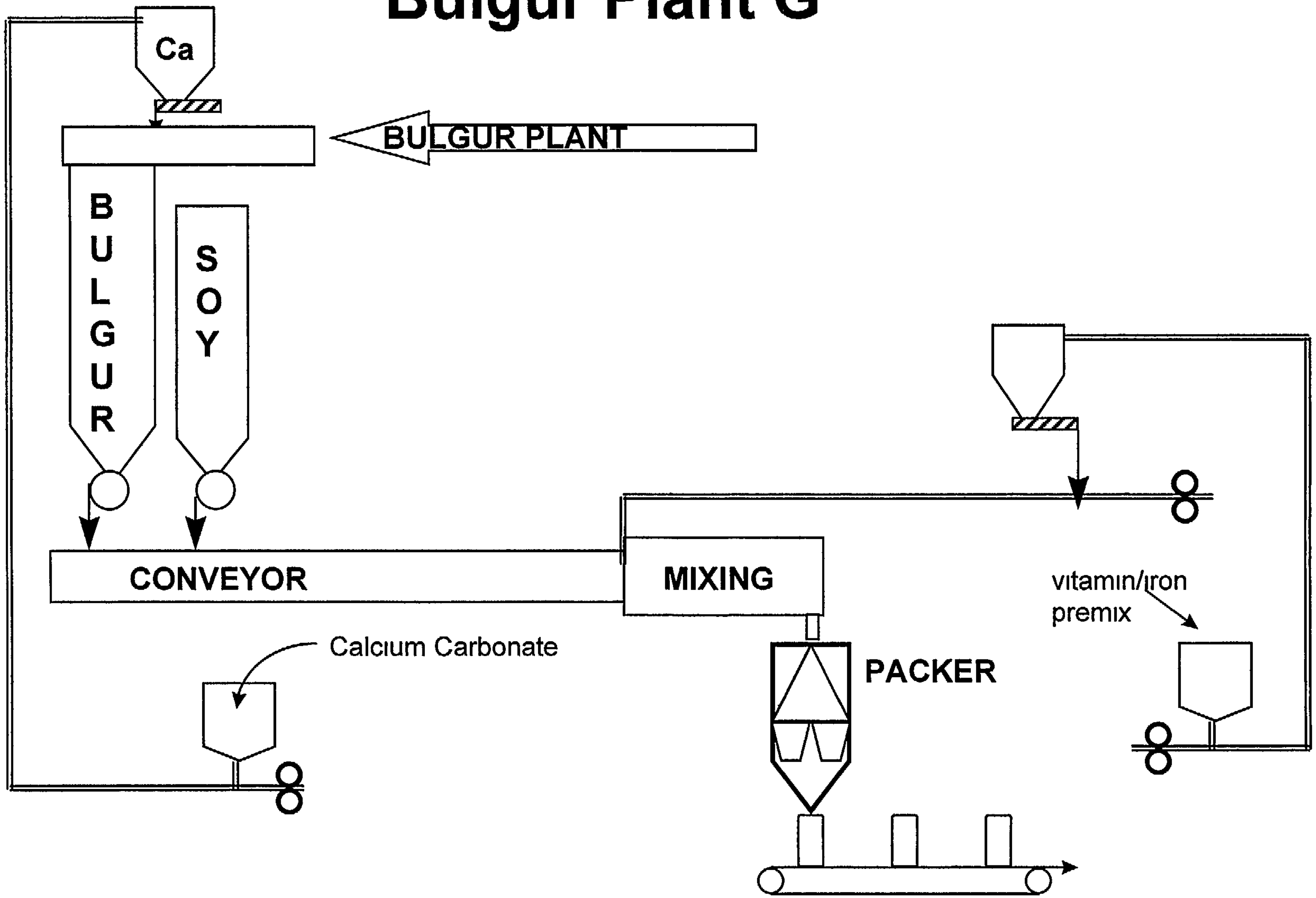
CSB Plant E


VITAMIN M IX
MINERAL M IX
TCP
BATCH RIBBON BLENDER
BELT FEEDER
AUGER
SOY FLOUR
PCM
OIL
BUCKET ELEVATOR
PACKER
MIXER
BAG SEALER

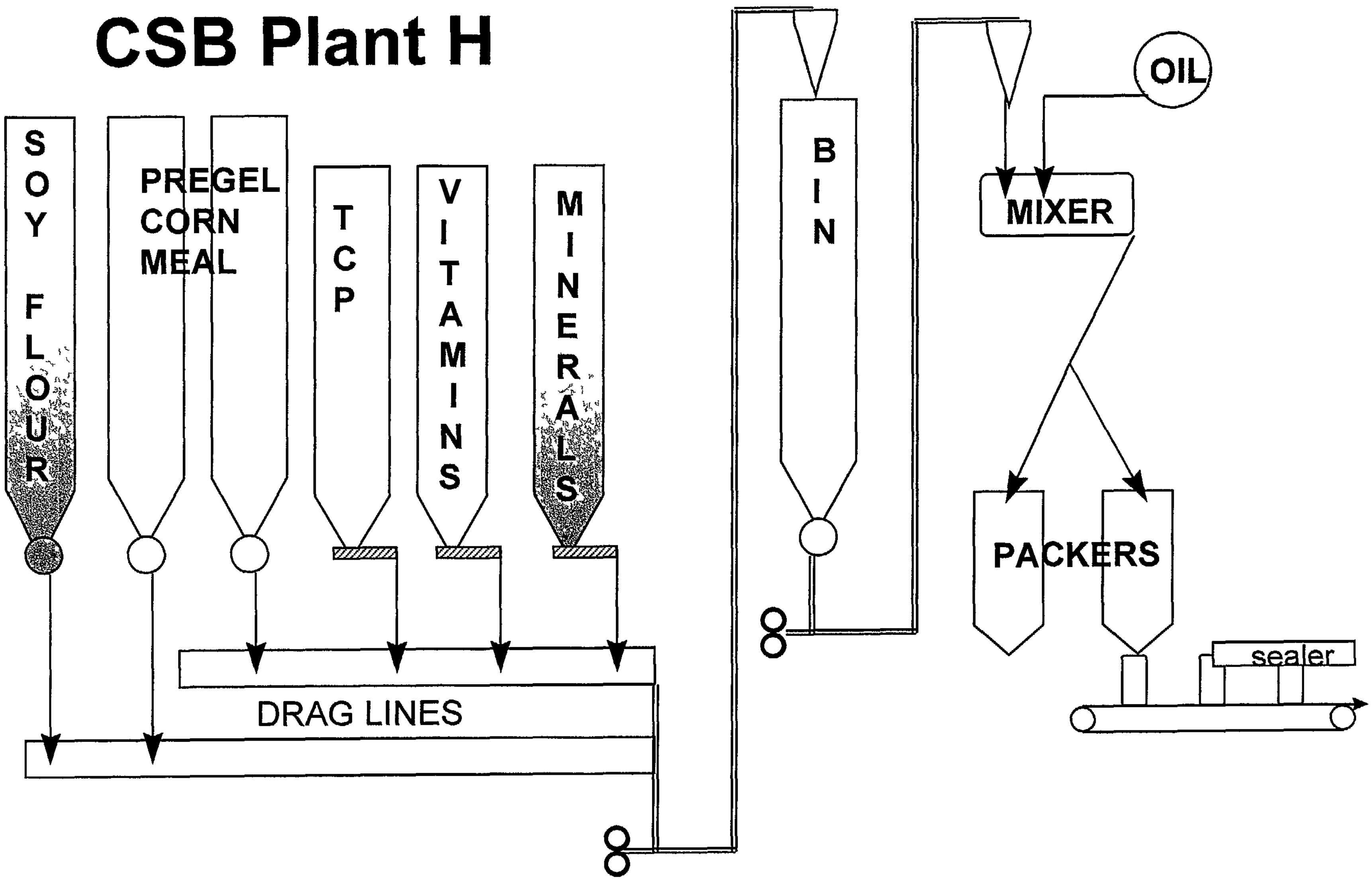
Wheat Flour Plant F



Bulgur Plant G



CSB Plant H


SOY FLOUR
PREGEL CORN MEAL
TCP
VITAMINS
MINERALS
DRAG LINES
BIN
OIL
MIXER
PACKERS
sealer

Appendix E
Explanation of Histograms and Control Charts on Plant Data

The Figures in this Appendix plot the plant data in two different ways histograms and control charts

The **histograms** on the top of each page are bar charts showing the frequency of a set range of micronutrient assays They allow easy visualization of the variation or uniformity in a set of data points The horizontal axis is the micronutrient content as a series of bins of equal magnitude The number is the midpoint of each bin Each micronutrient has the same scale allowing for easy comparison The vertical axis is the number of samples whose assay for that micronutrient fell within each bin

The **control charts** on the bottom of each page show how the micronutrient assays varied with time The horizontal axis represents each sequential sample arranged in order from the earliest time sampled on the far left to the latest time sampled on the far right The vertical axis is the micronutrient content Each micronutrient has the same scale allowing for easy comparison

Shown on the control chart is a heavy horizontal line representing the target level, in the case of CSB and WSB, or the minimum level, in the case of wheat flour A shaded horizontal bar is shown for corn meal and bulgur The top of the bar is the maximum level and the bottom of the bar is the minimum level The actual standards are given in Table 4 for the fortified processed foods and Table 5 for CSB and WSB

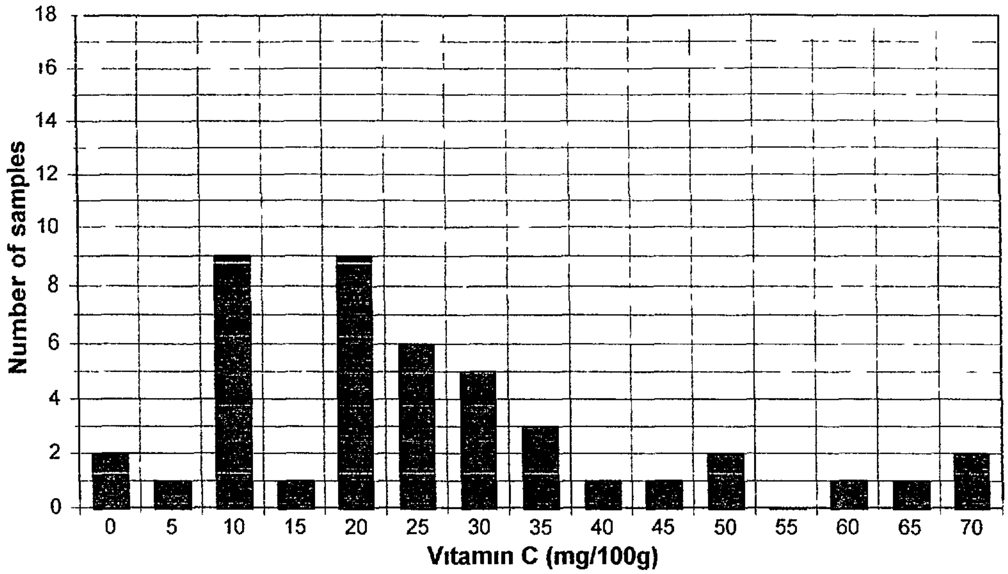
Also shown on the right side of each control chart is the NIST standard, representing the analytical error for each micronutrient assay Each day a set of samples were tested for a particular micronutrient, a standard reference sample with a certified level of that micronutrient was tested as well If the assay results on that standard fell outside of the range shown by the NIST standard bar on the graph, the results were discarded and repeated The length of the bar then represents the allowable analytical error for that assay

On the bottom of each page is a box giving numerical values on each set of samples

- The **number** (N) of samples collected and tested for the micronutrient
- The arithmetic **mean** micronutrient level of the set of samples, or the sum of all the values divided by N
- The **standard deviation**, or the square root of the average difference between each value and the mean, of the set of micronutrient levels
- The **COV** or coefficient of variation, which is the standard deviation as a percentage of the mean

Fig 1 - Vitamin C in CSB at Plant A

Histogram



Control Chart

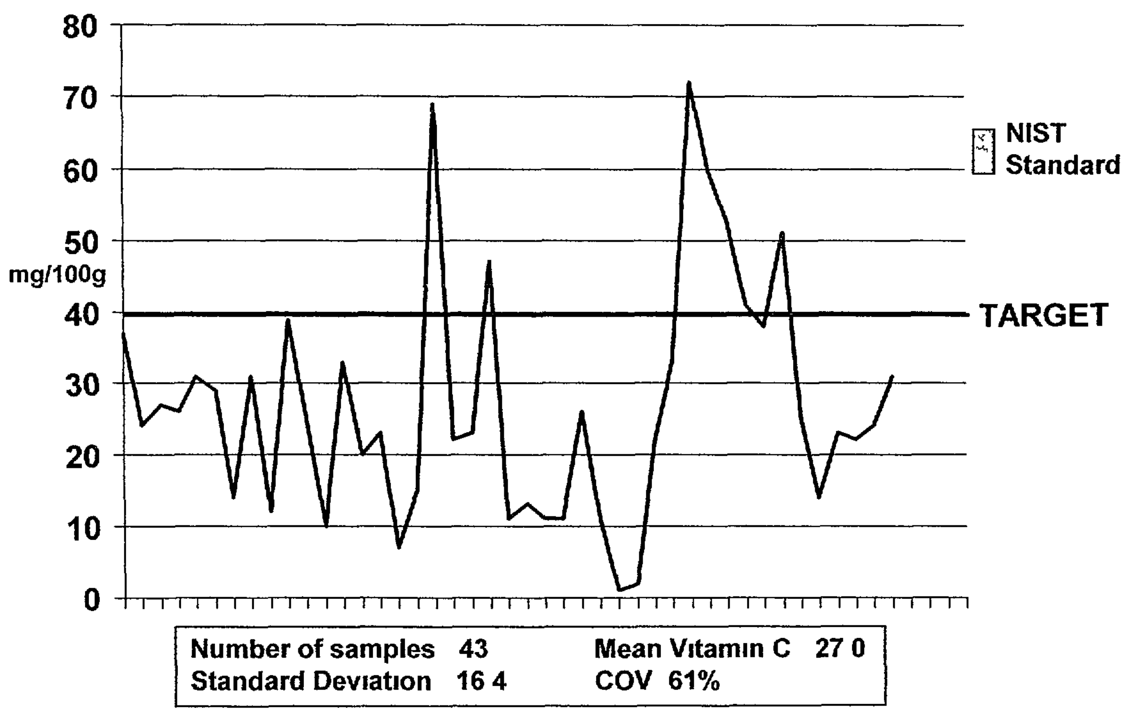
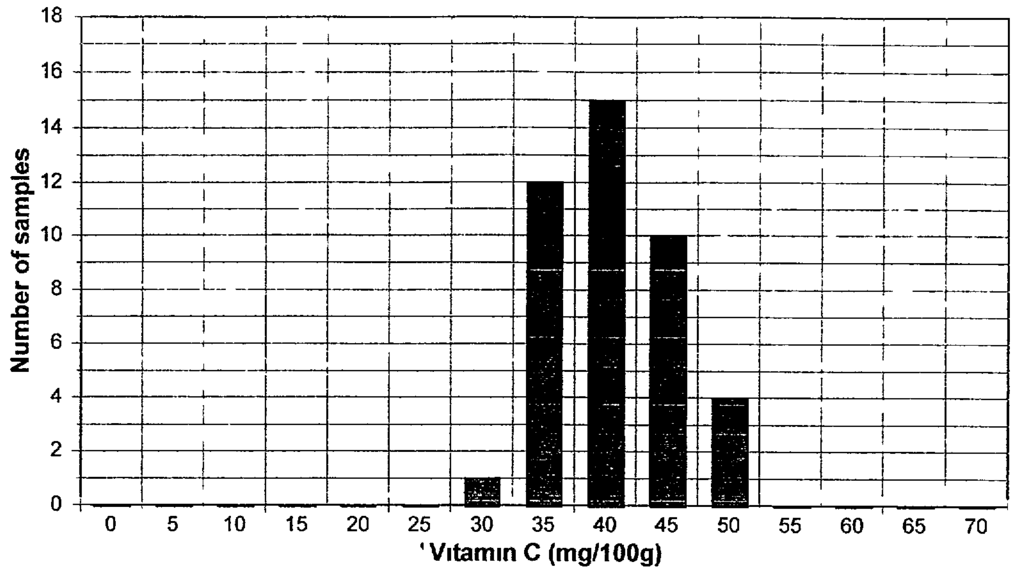
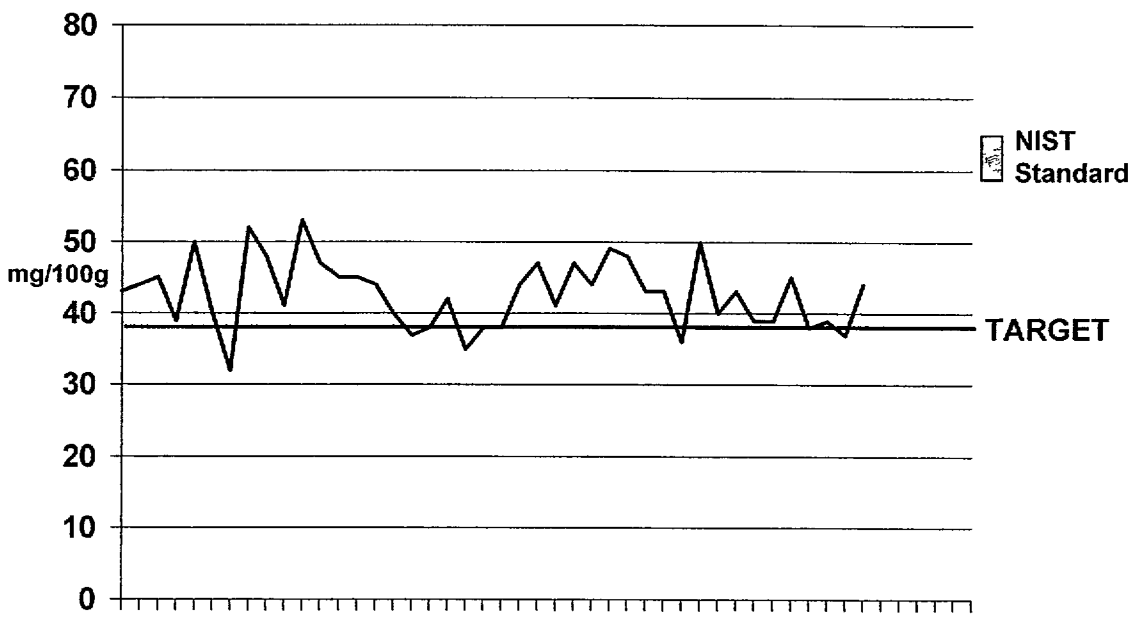


Fig 2 - Vitamin C in WSB at Plant B

Histogram



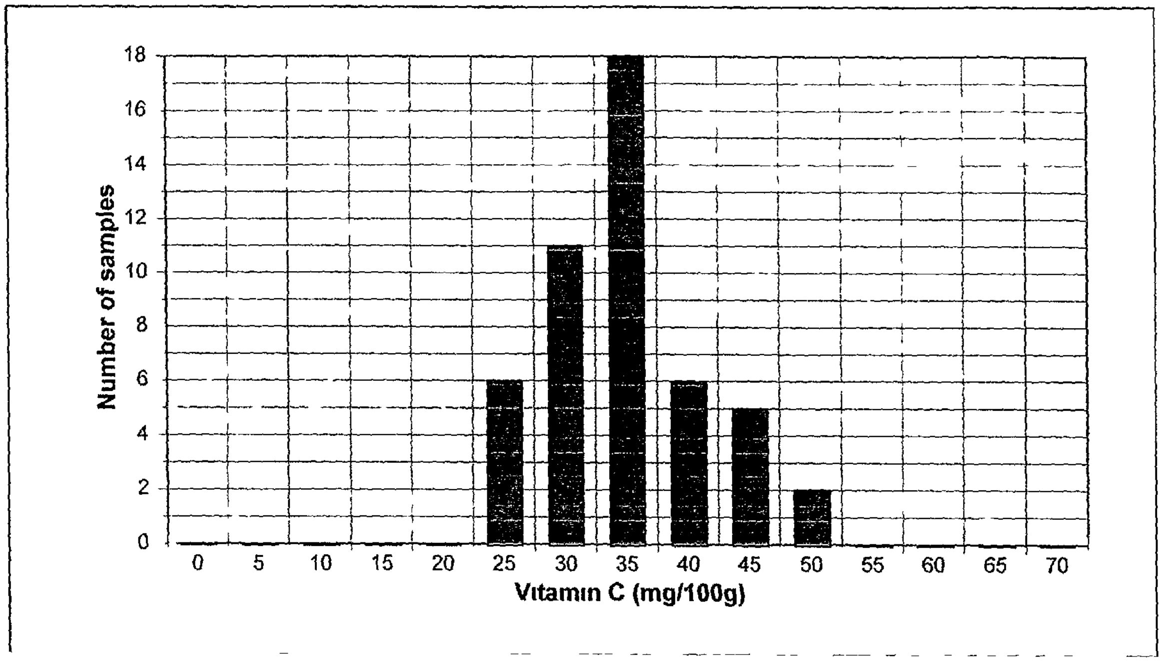
Control Chart



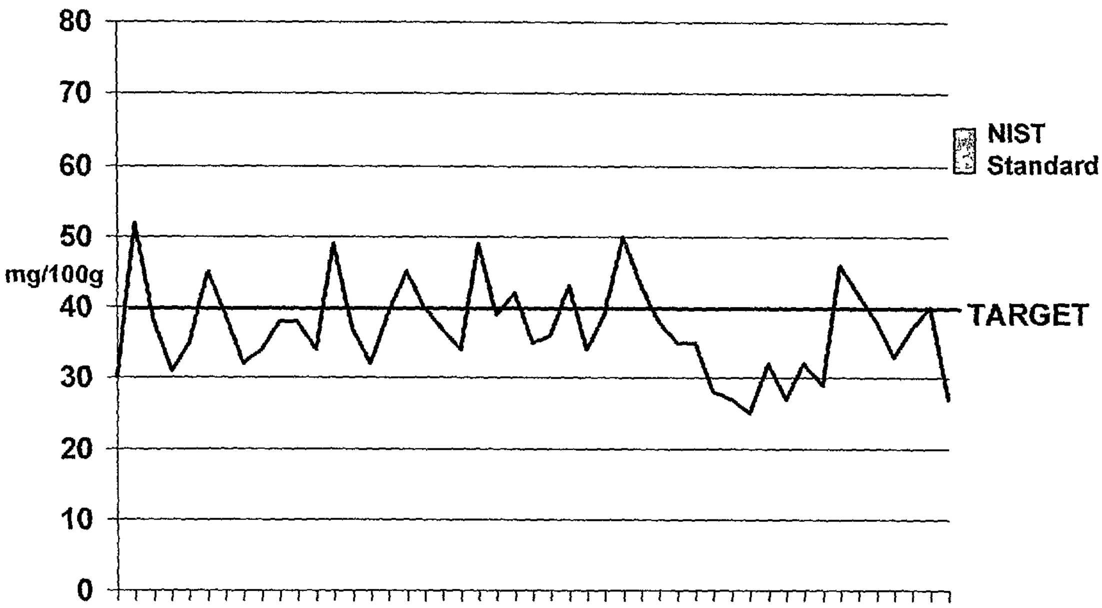
Number of samples 42	Mean Vitamin C 42 7
Standard Deviation 4 7	COV 11%

Fig 3 - Vitamin C in CSB at Plant C

Histogram



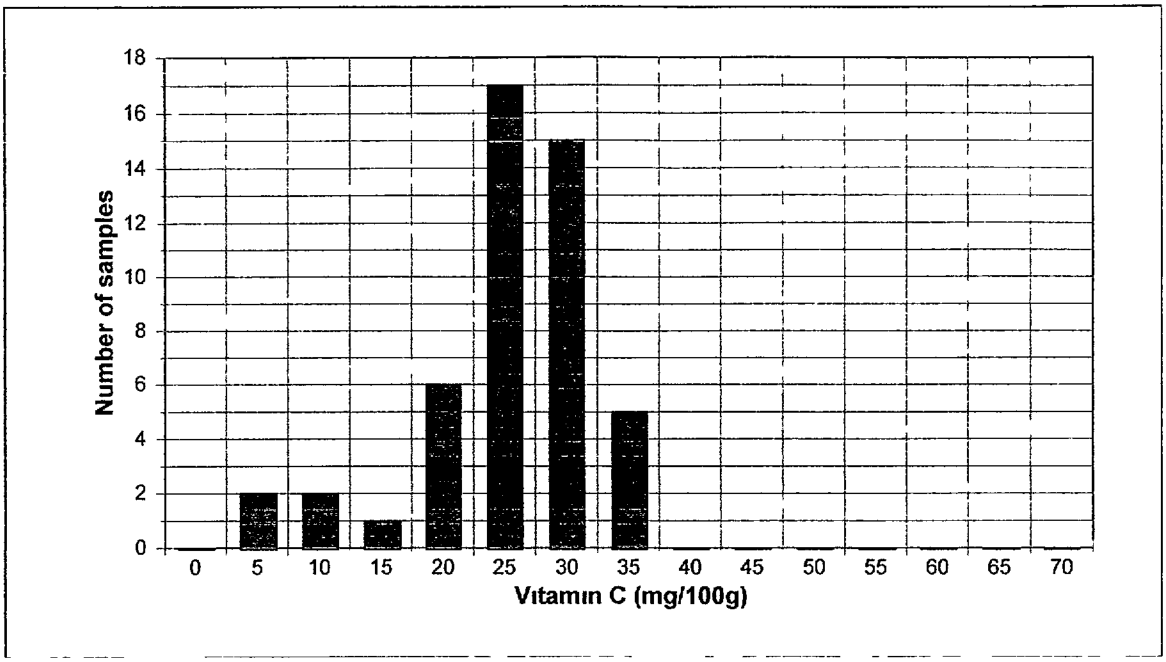
Control Chart



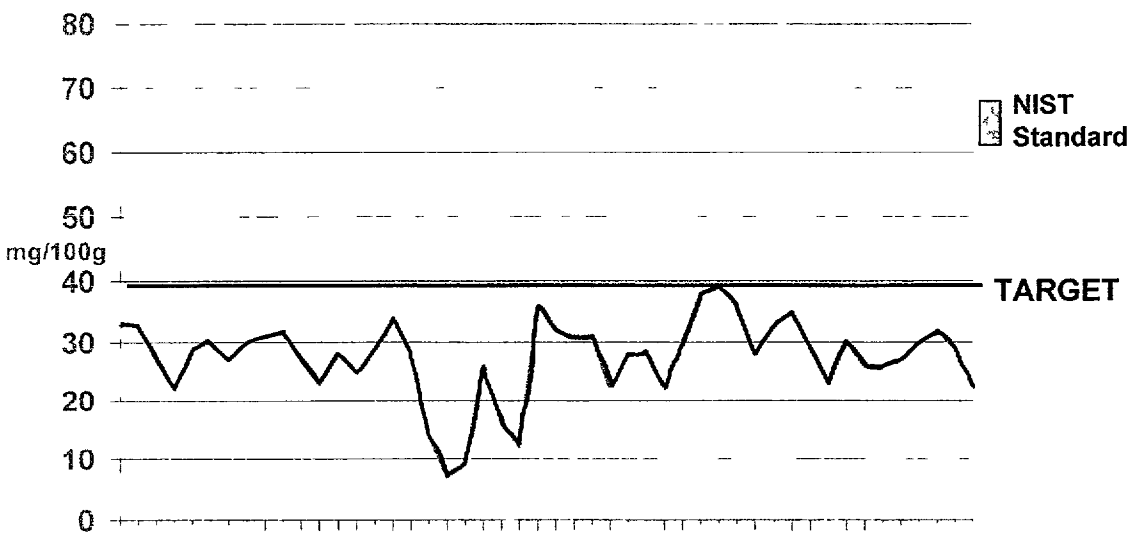
Number of samples 47	Mean Vitamin C 37 0
Standard Deviation 7 4	COV 17%

Fig 4 - Vitamin C in CSB at Plant D

Histogram



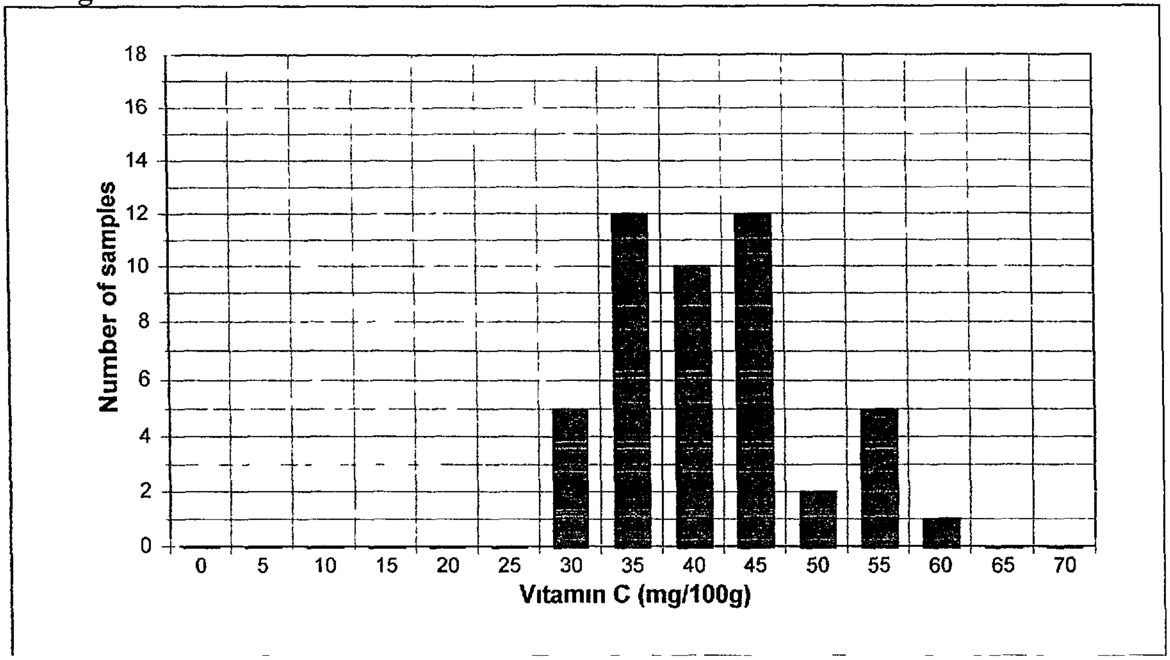
Control Chart



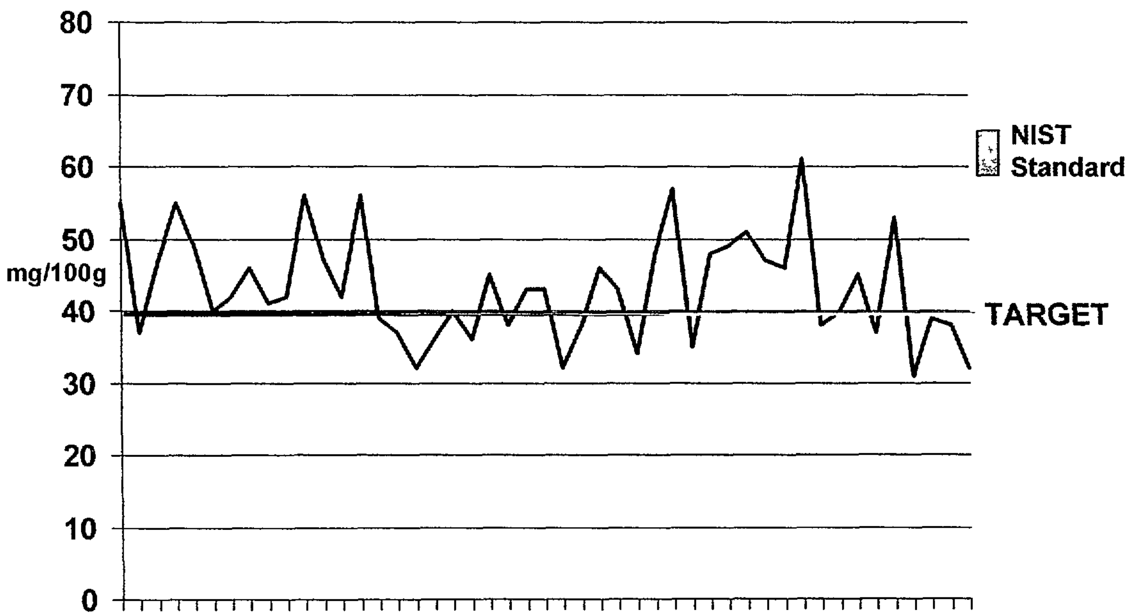
Number of samples 48	Mean Vitamin C 27 4
Standard Deviation 6 8	COV 25%

Fig 5 - Vitamin C in CSB at Plant E

Histogram



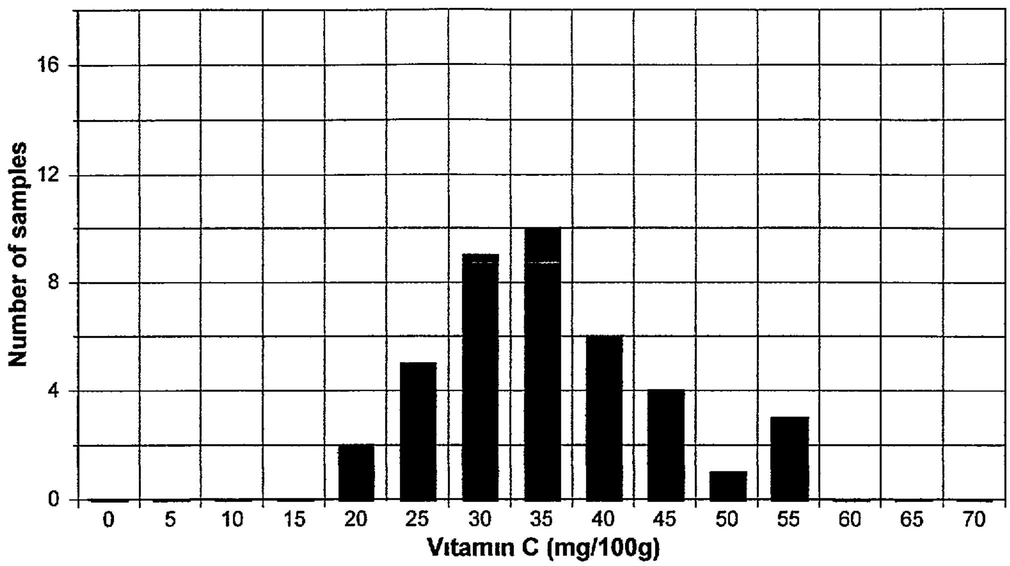
Control Chart



Number of samples 47	Mean Vitamin C 43 2
Standard Deviation 7 4	COV 17%

Fig 6 - Vitamin C in CSB at Plant G

Histogram



Control Chart

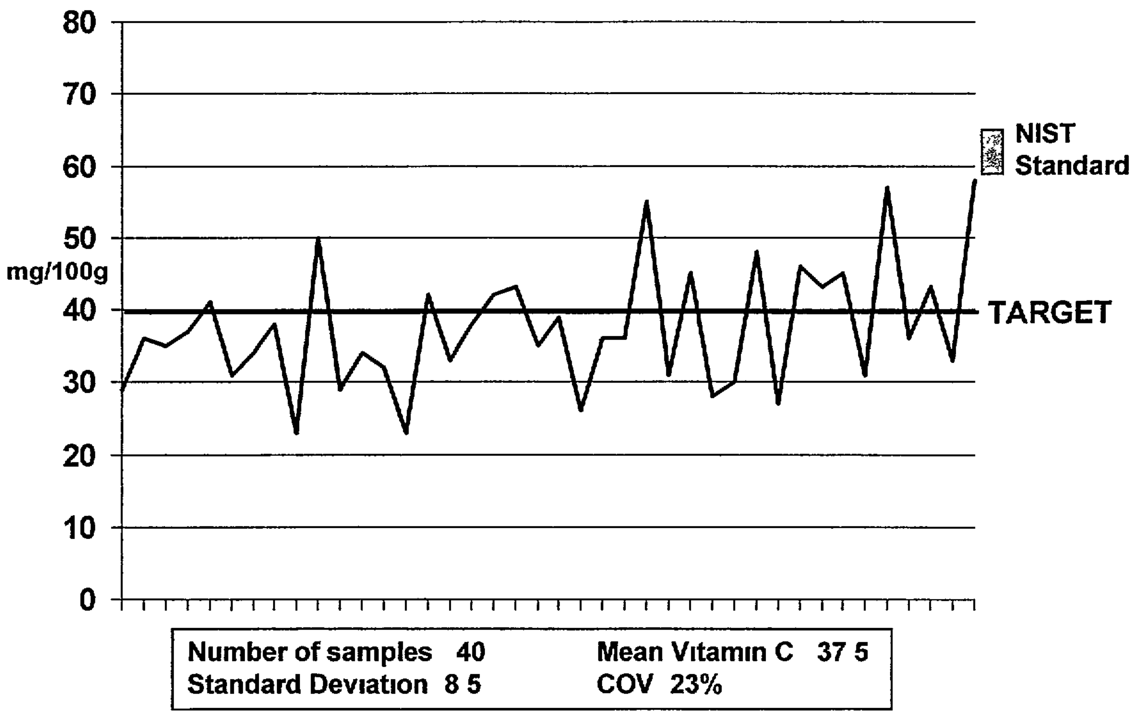
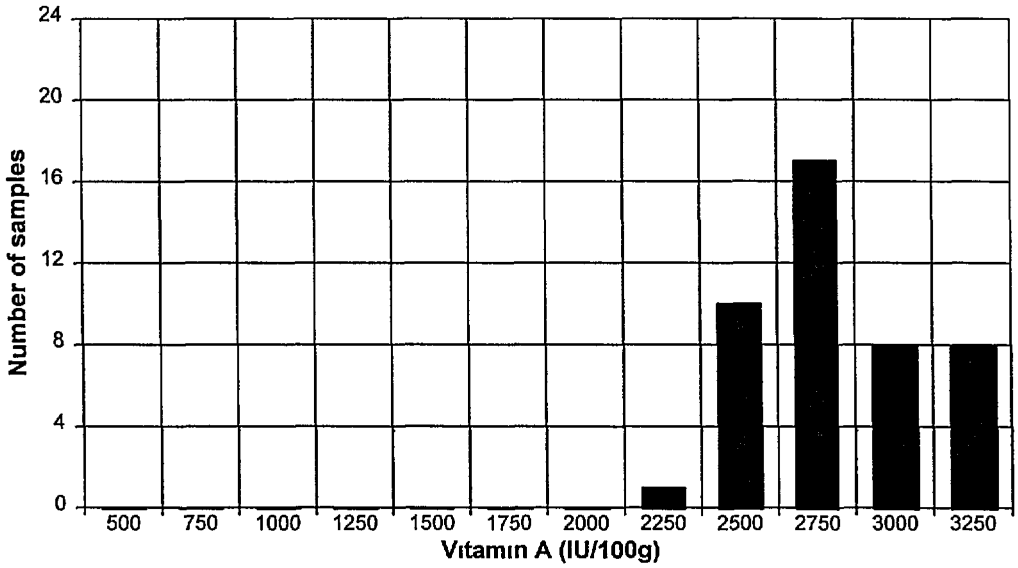


Fig 7 - Vitamin A in WSB at Plant B

Histogram



Control Chart

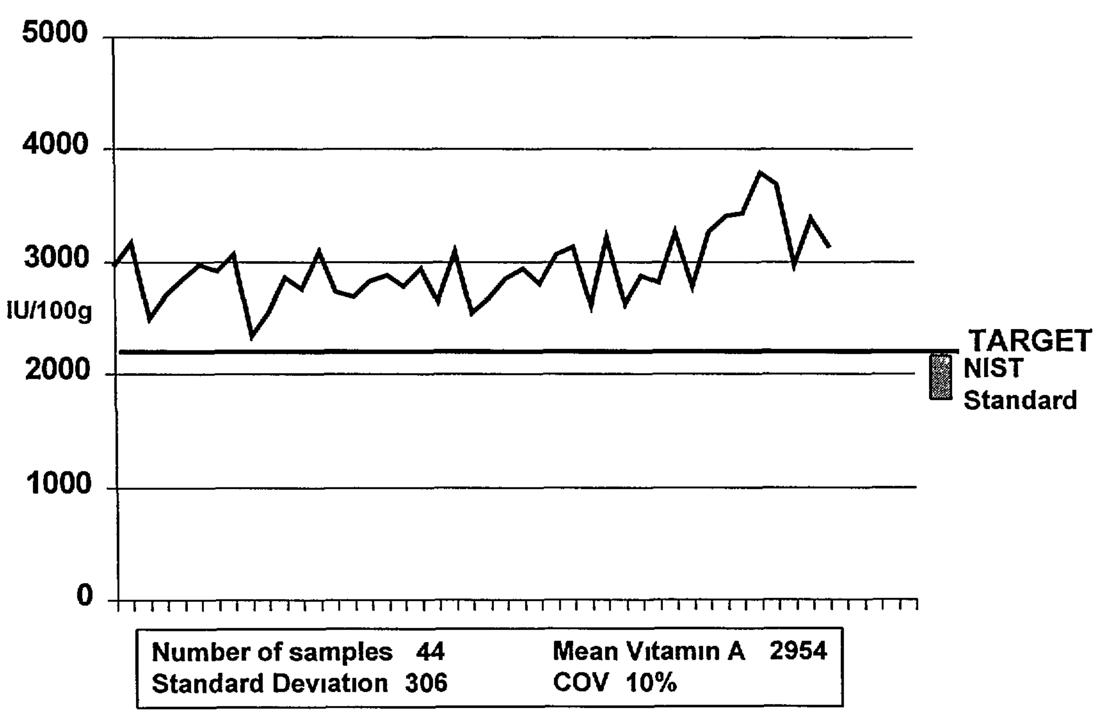
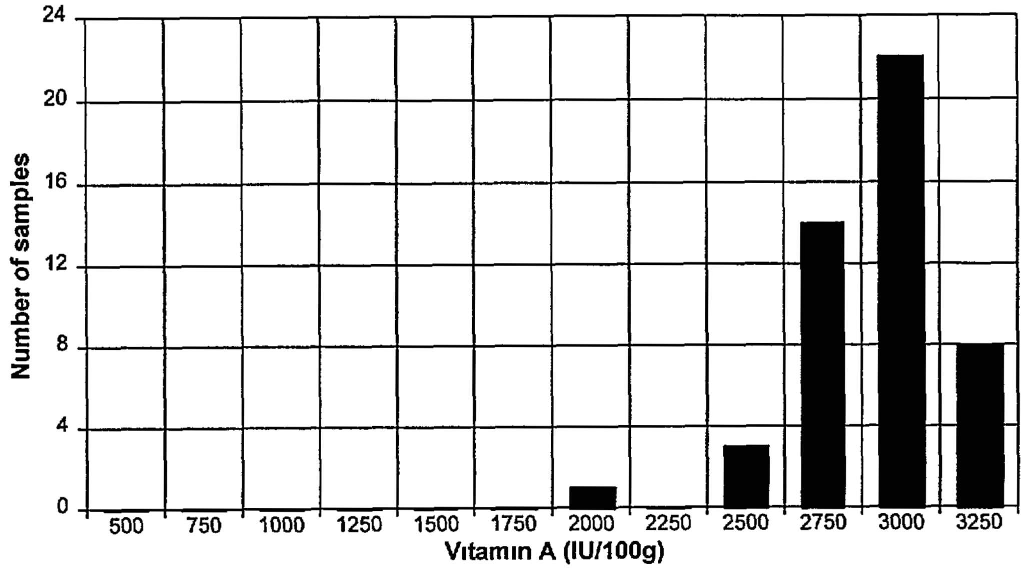


Fig 8 - Vitamin A in Corn Meal at Plant C

Histogram



Control Chart

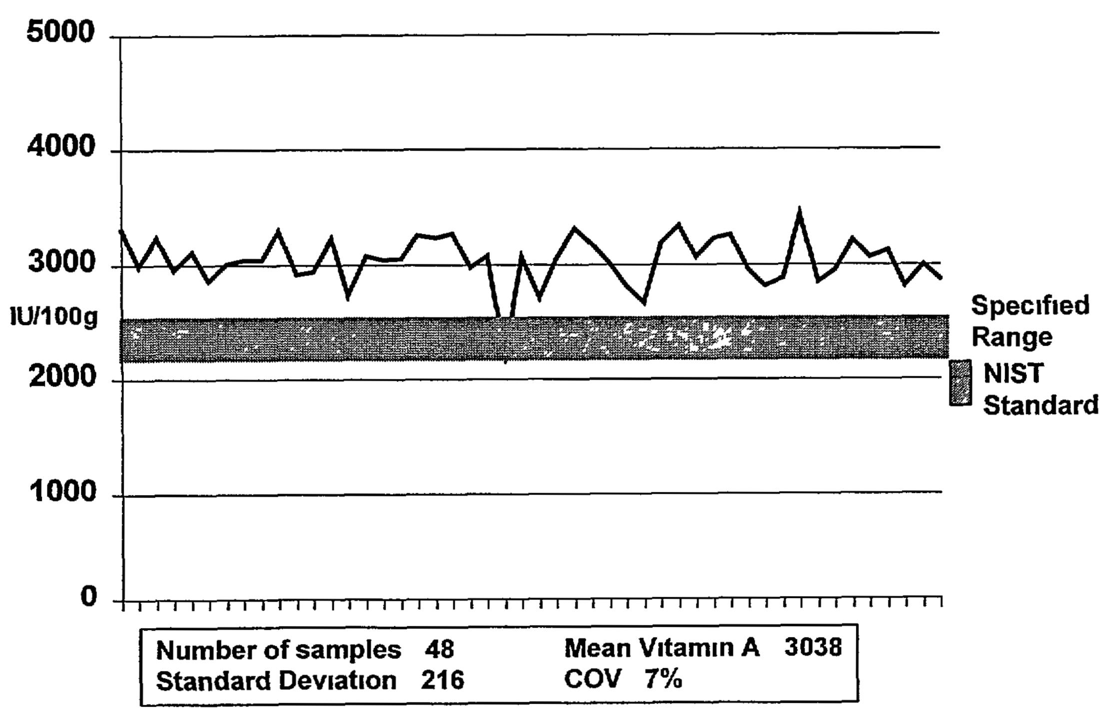
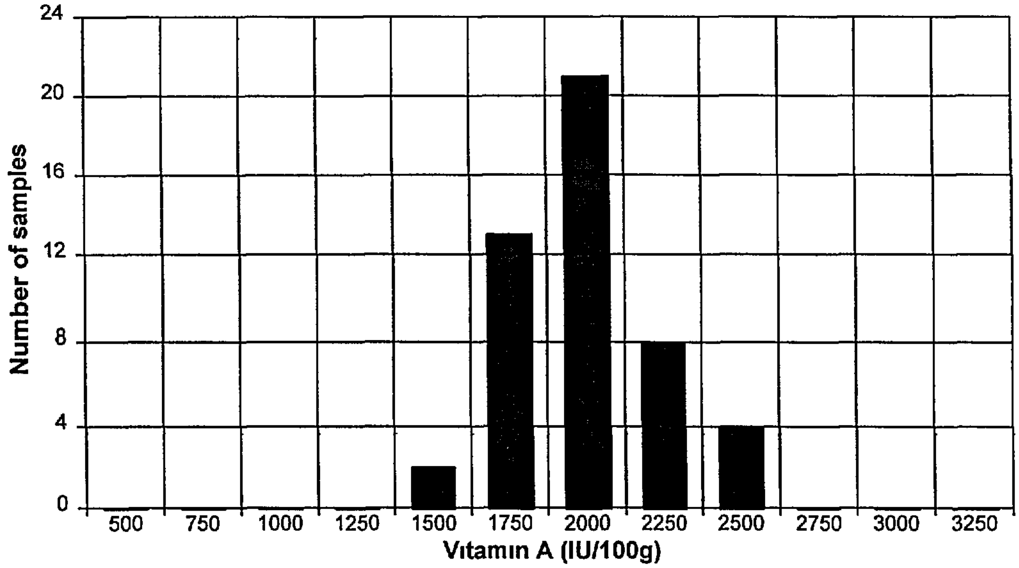
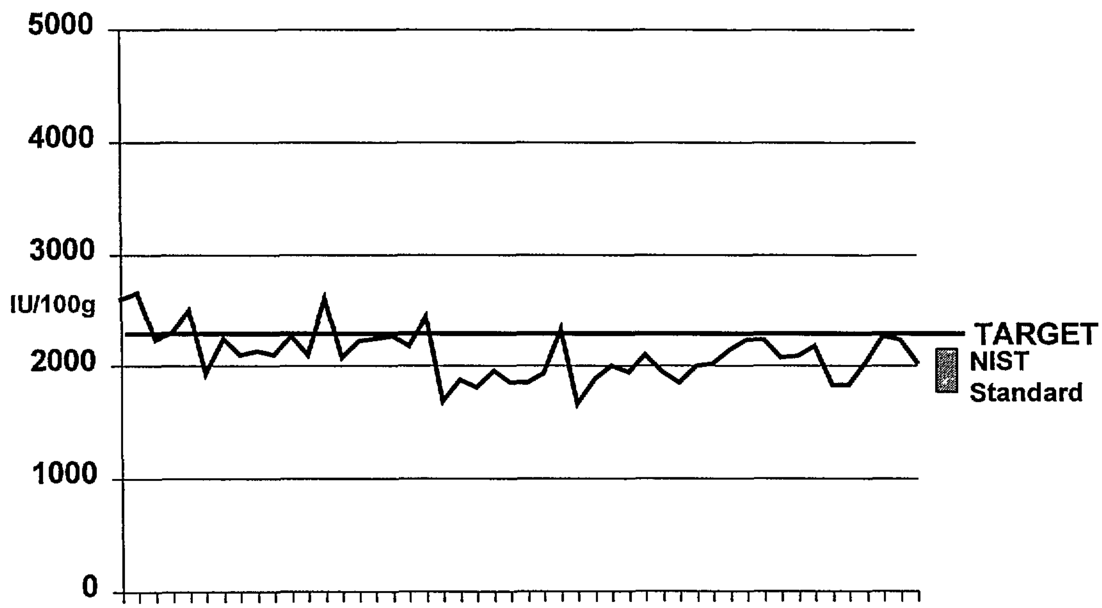


Fig 9 - Vitamin A in CSB at Plant C

Histogram



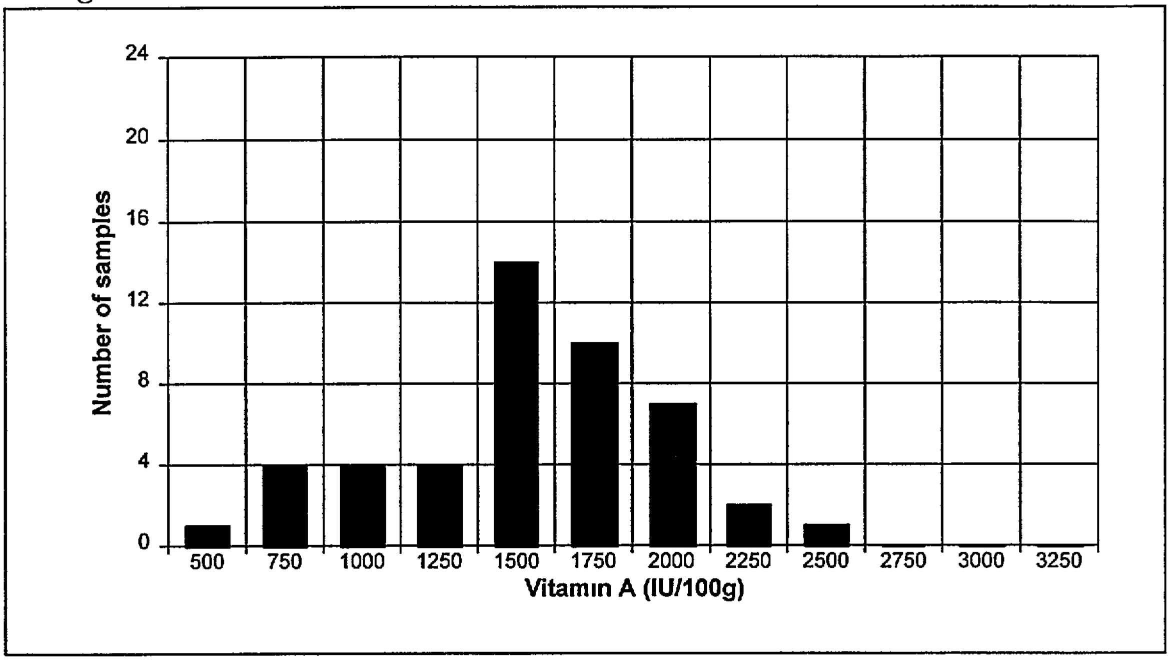
Control Chart



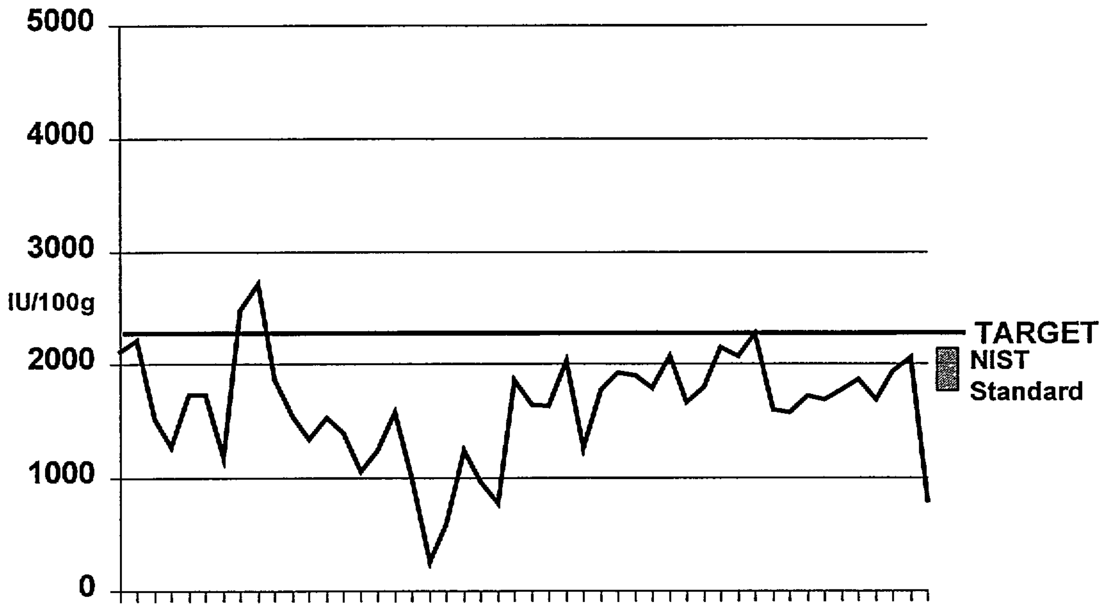
Number of samples 47	Mean Vitamin A 2110
Standard Deviation 227	COV 11%

Fig 10 - Vitamin A in CSB at Plant D

Histogram



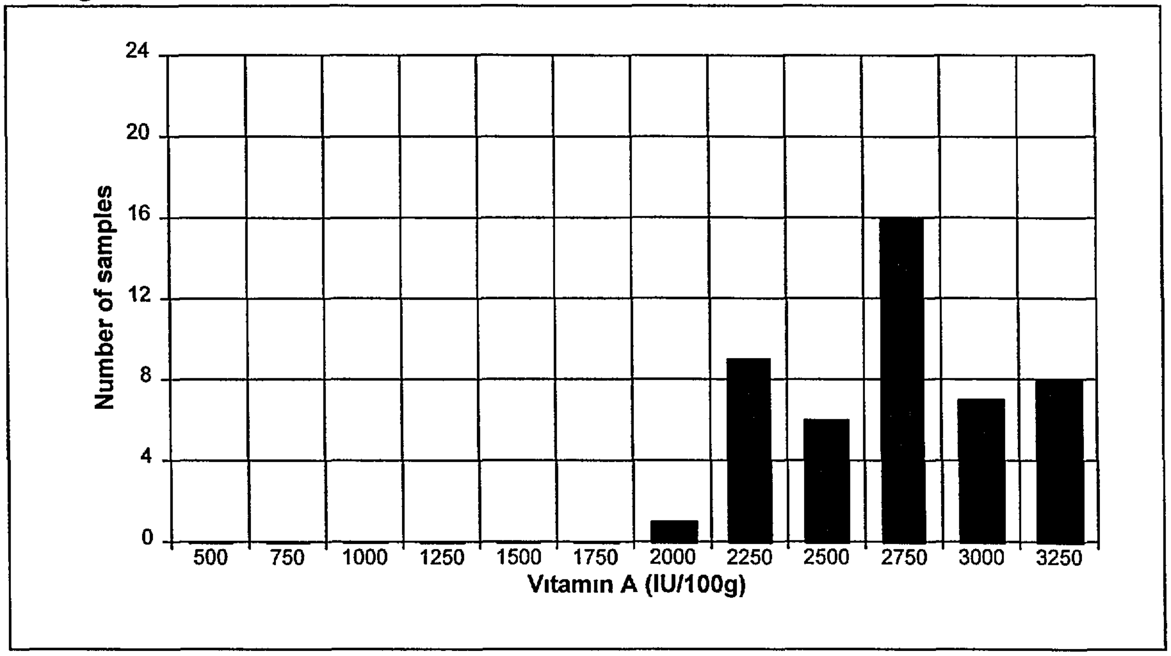
Control Chart



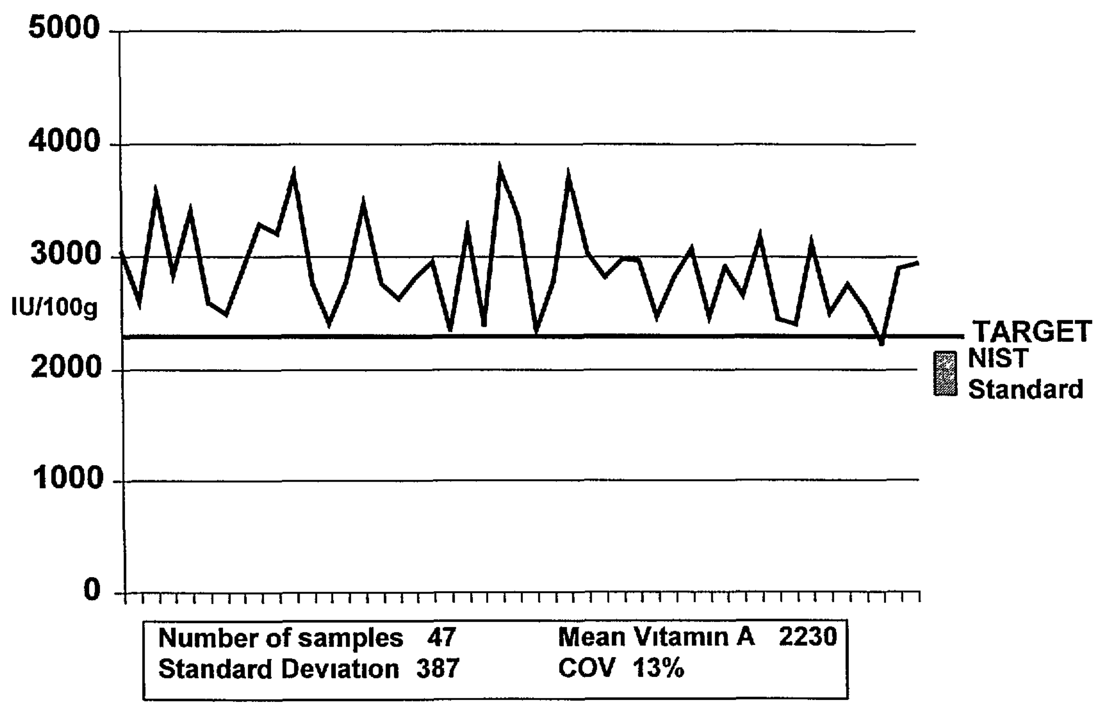
Number of samples 48	Mean Vitamin A 1620
Standard Deviation 479	COV 30%

Fig 11 - Distribution of Vitamin A in CSB at Plant E

Histogram



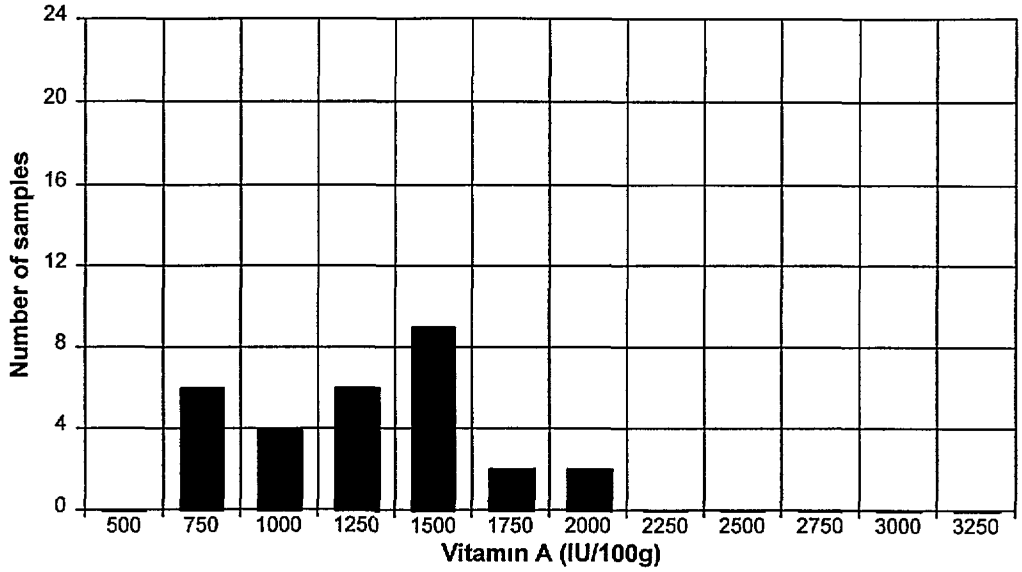
Control Chart



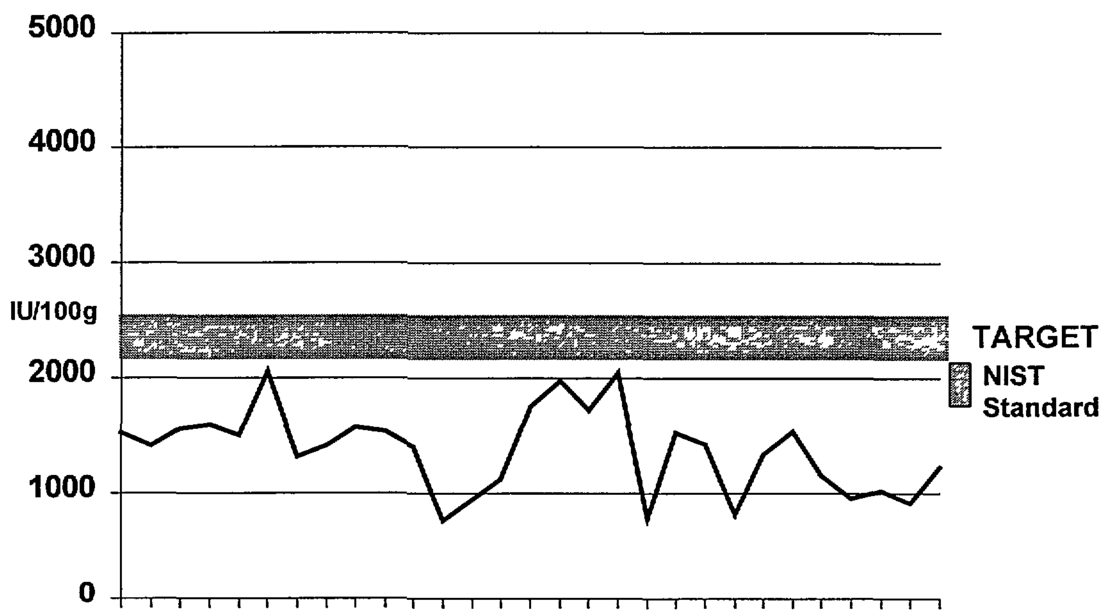
130

Fig 12 - Vitamin A in Wheat Flour at Plant F

Histogram



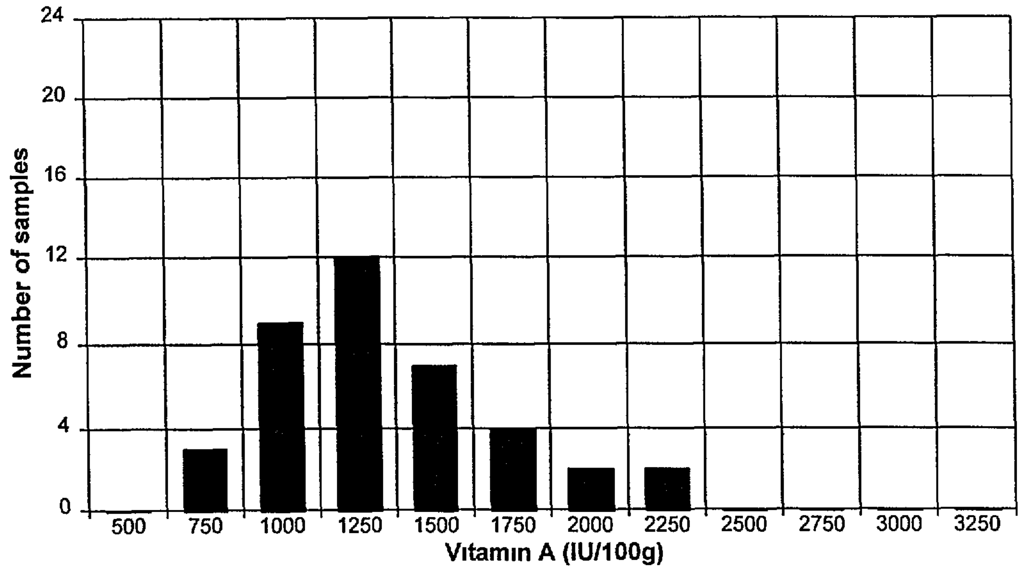
Control Chart



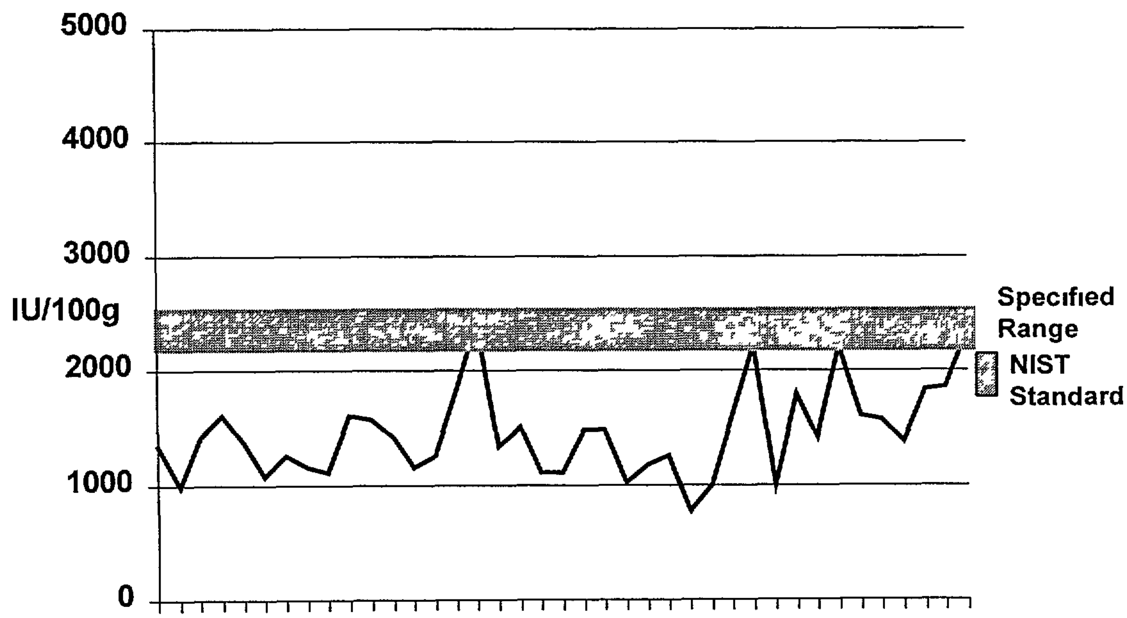
Number of samples	29	Mean Vitamin A	1374
Standard Deviation	389	COV	26%

Fig 13 - Vitamin A in Soy Fortified Bulgur at Plant G

Histogram



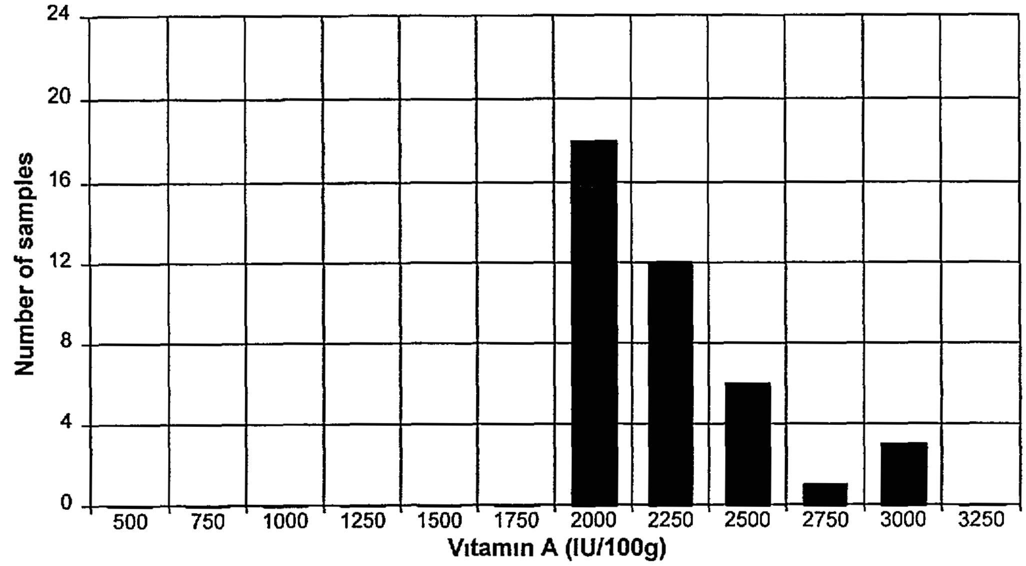
Control Chart



Number of samples 39	Mean Vitamin A 1451
Standard Deviation 385	COV 27 %

Fig 14 - Vitamin A in CSB at Plant H

Histogram



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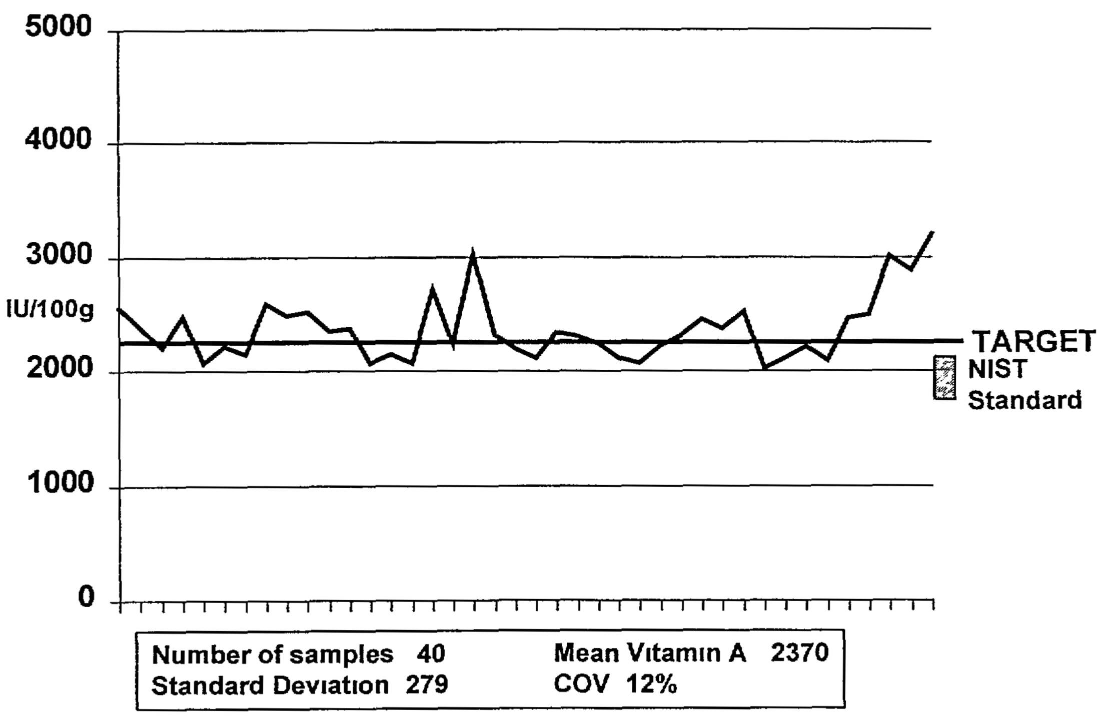
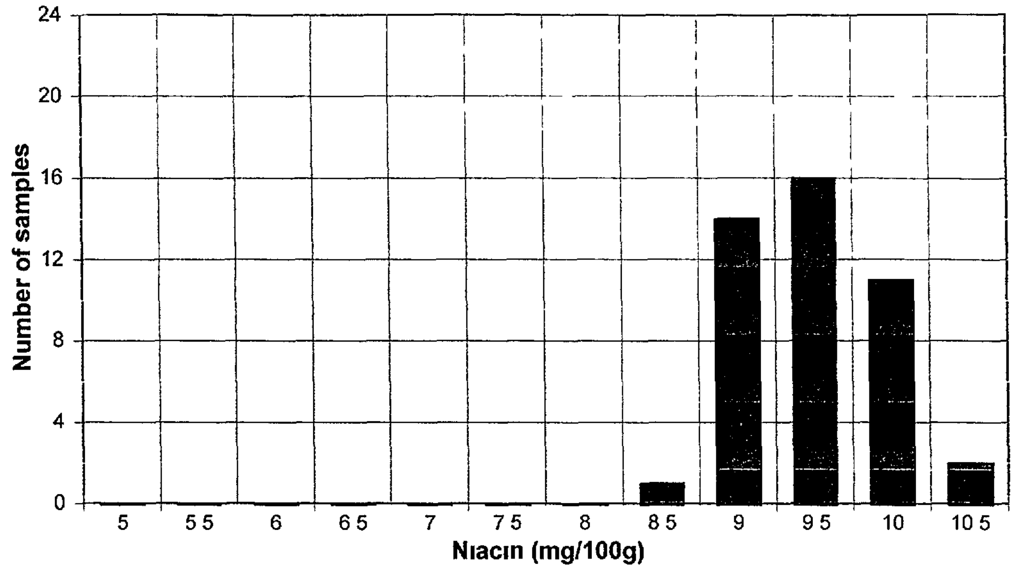
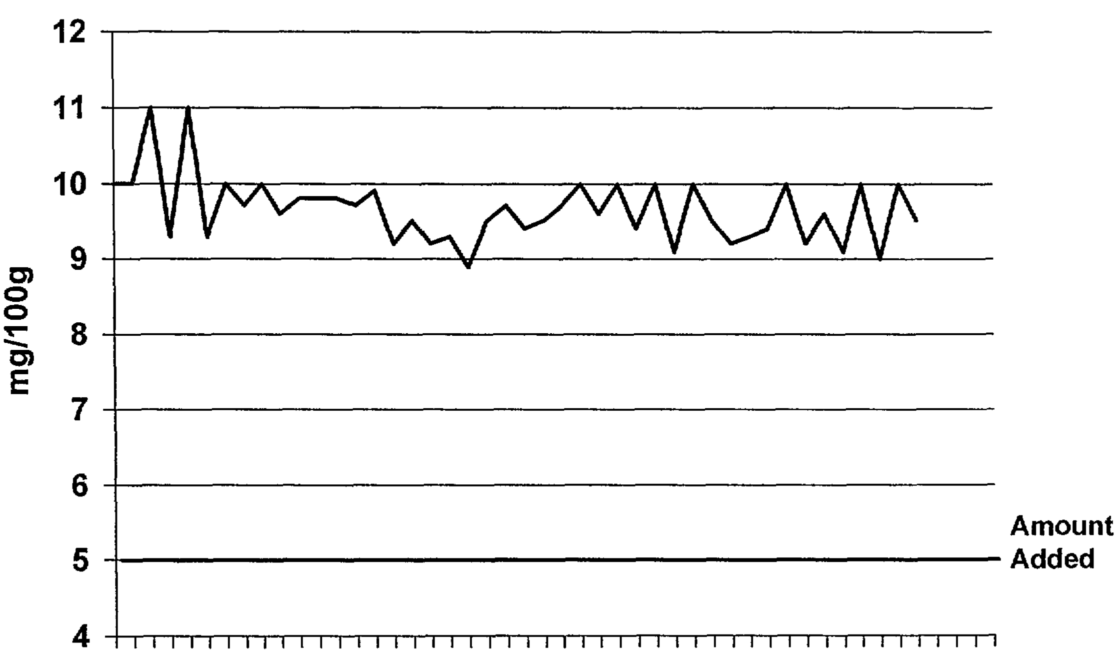


Fig 15 - Niacin in WSB at Plant B

Histogram



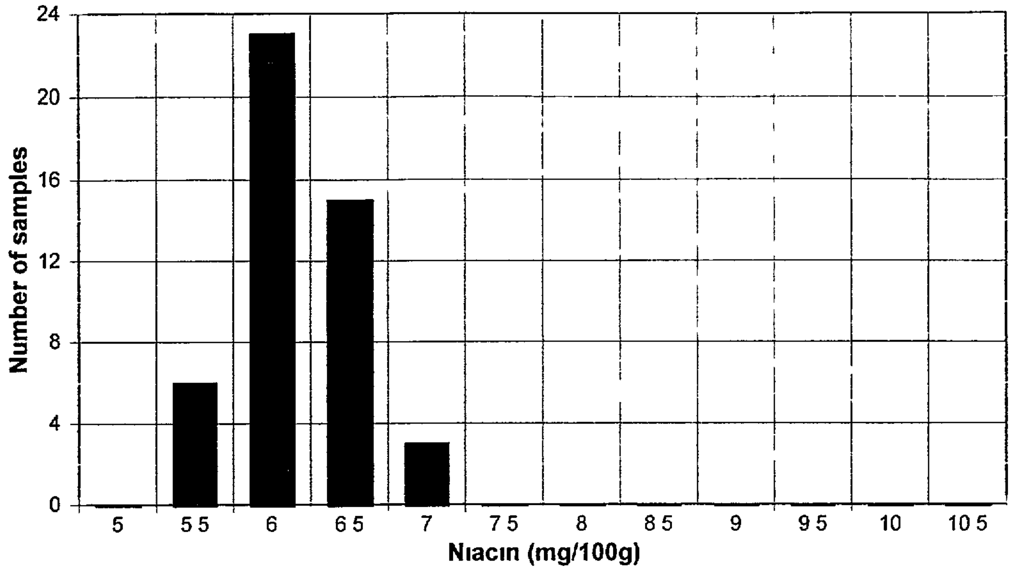
Control Chart



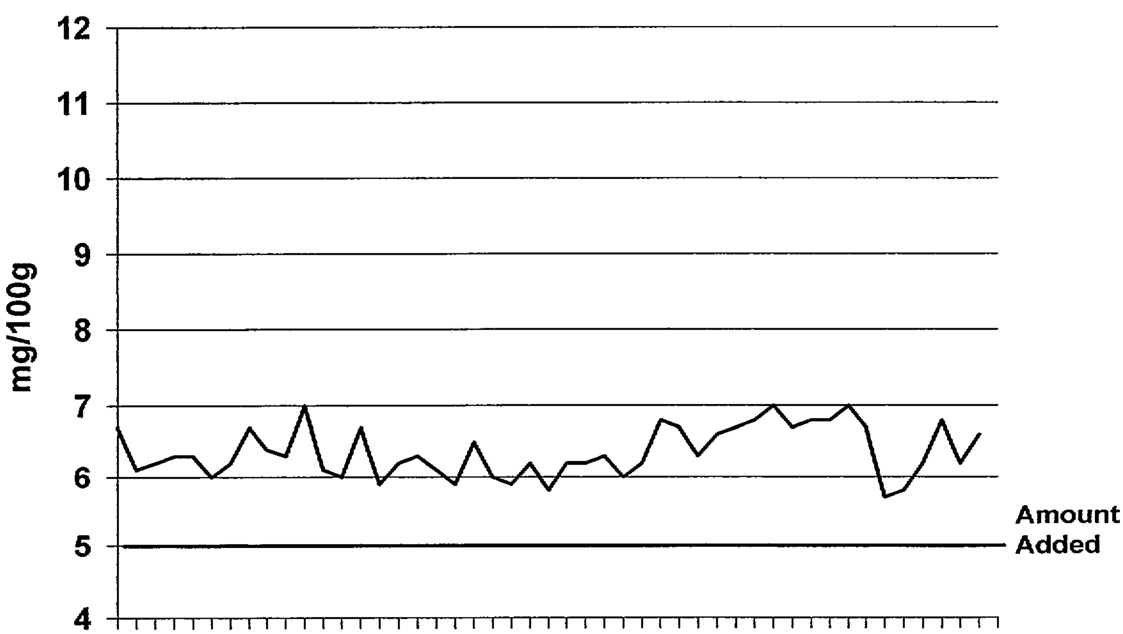
Number of samples 44	Mean Niacin 9 7
Standard Deviation 0 4	COV 5%

Fig 16 - Niacin in CSB at Plant C

Histogram



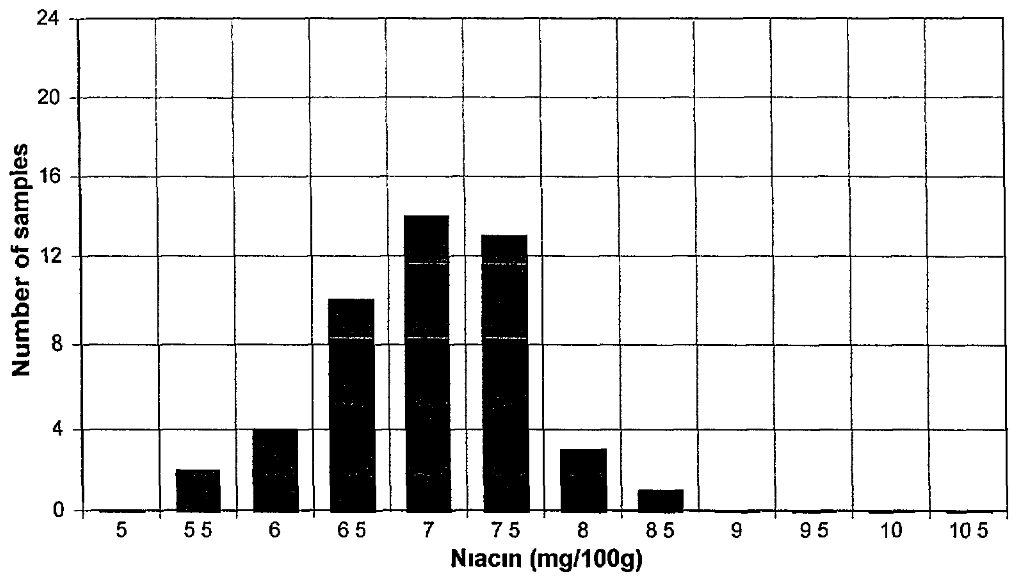
Control Chart



Number of samples 47	Mean Niacin 6 4
Standard Deviation 0 6	COV 6%

Fig 17 - Niacin in CSB at Plant E

Histogram



Control Chart

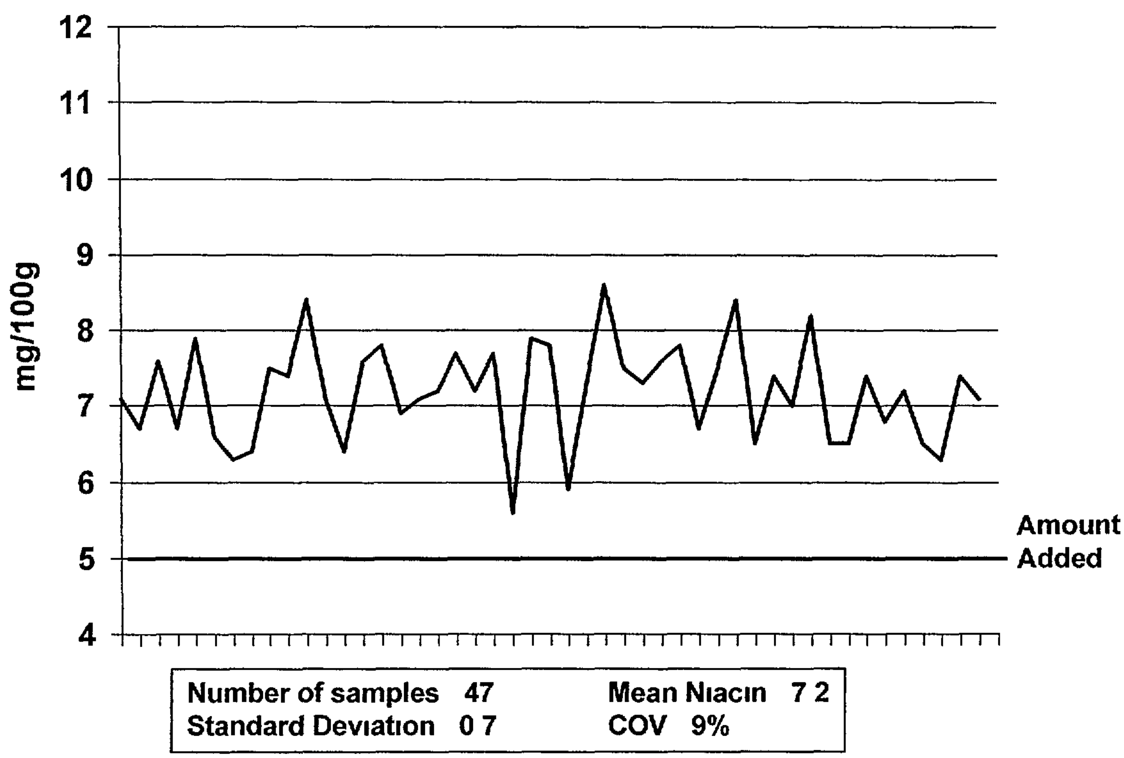
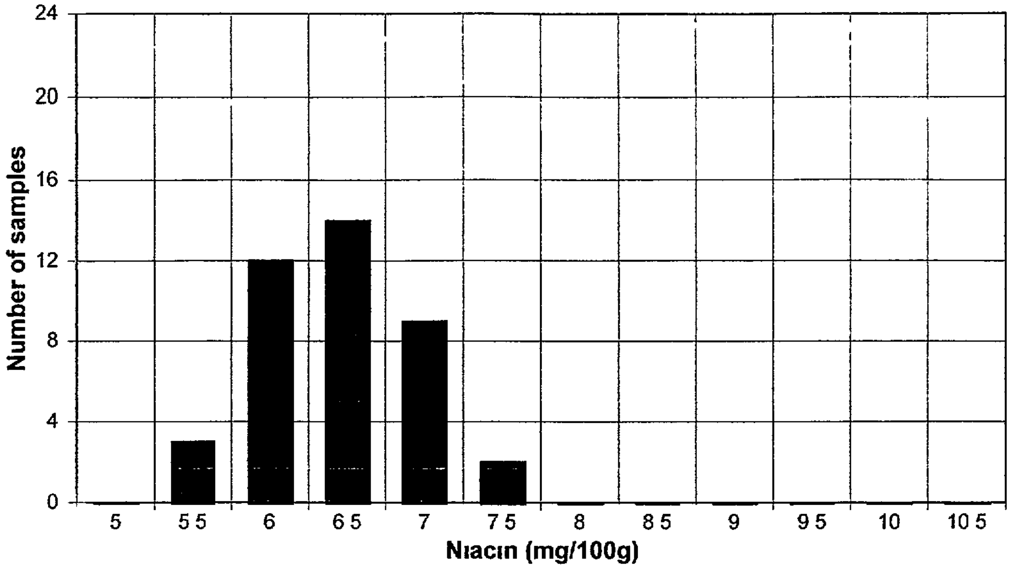
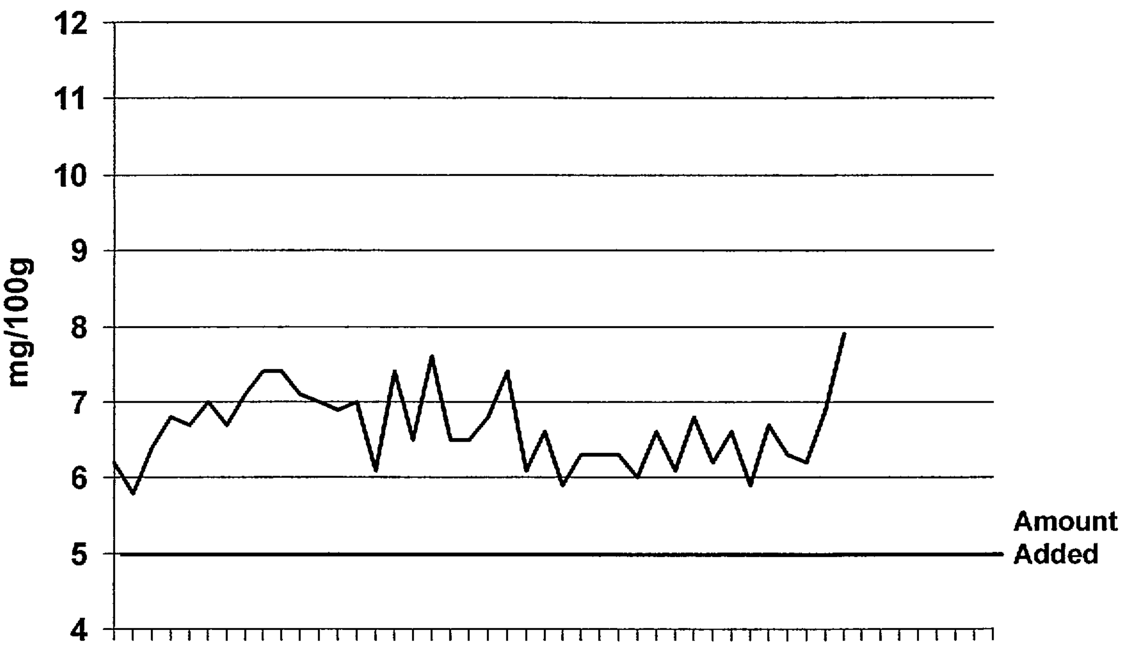


Fig 18 - Niacin in CSB at Plant H

Histogram



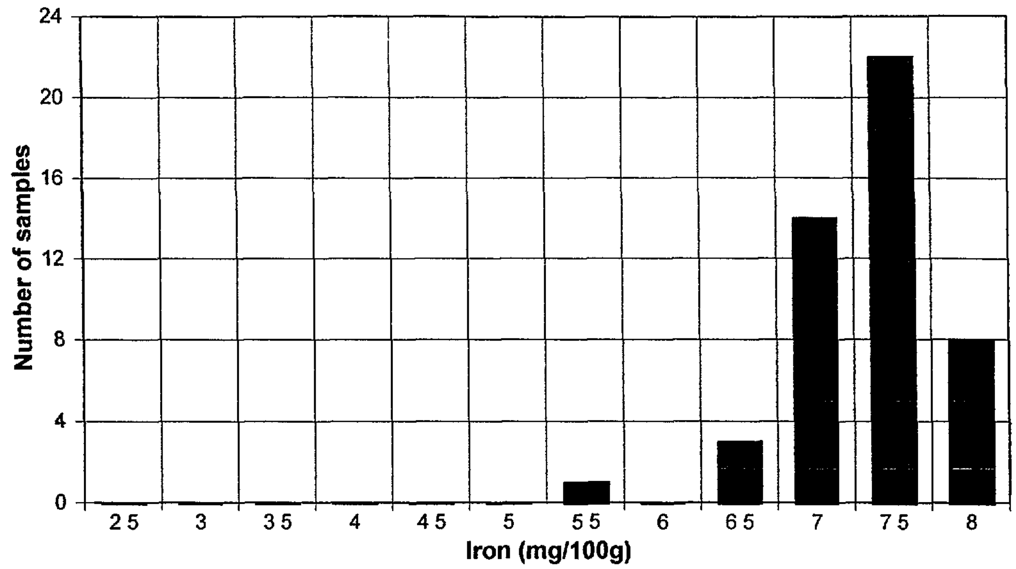
Control Chart



Number of samples 40
Standard Deviation 0 5
Mean Niacin 6 7
COV 8%

Fig 19 - Iron in Corn Meal at Plant C

Histogram



Control Chart

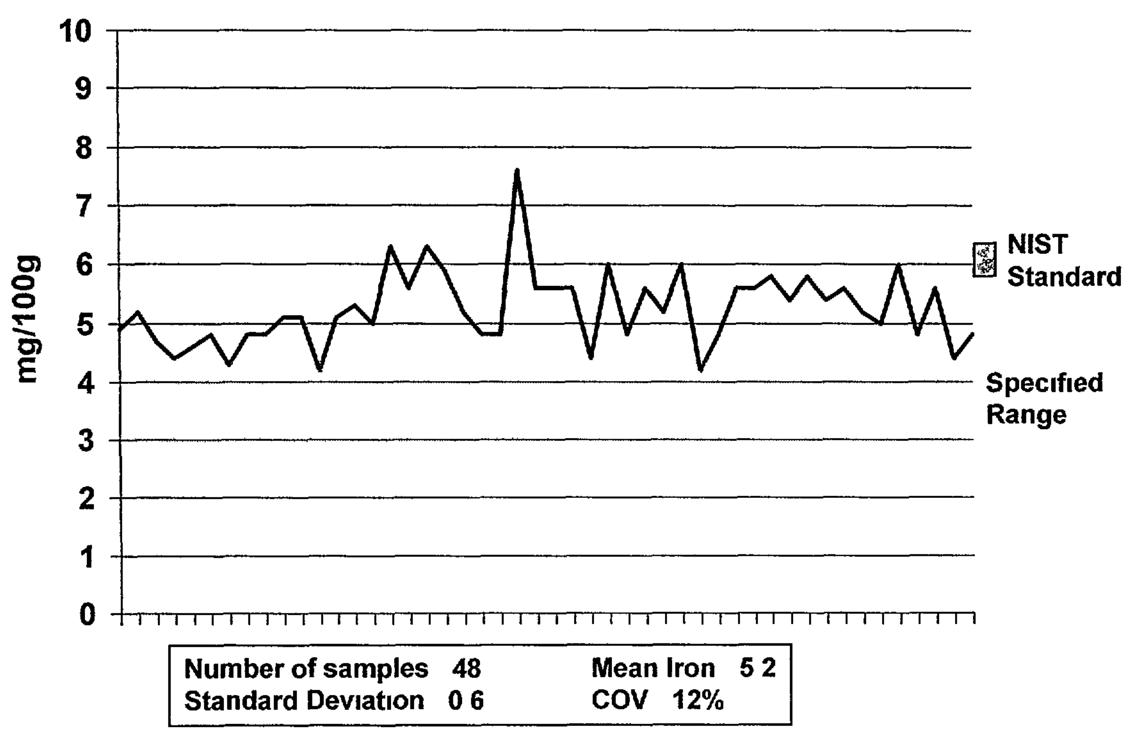
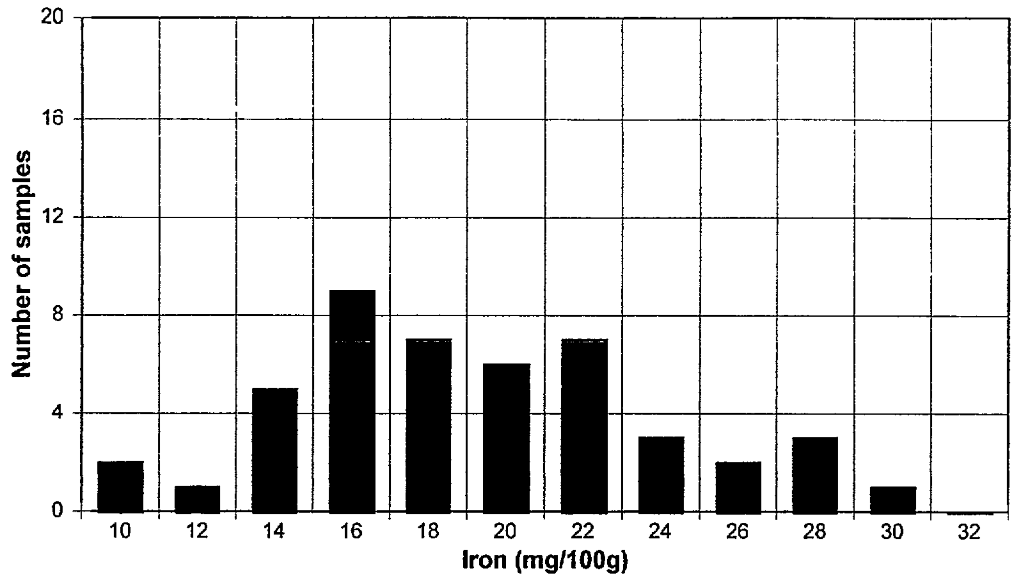
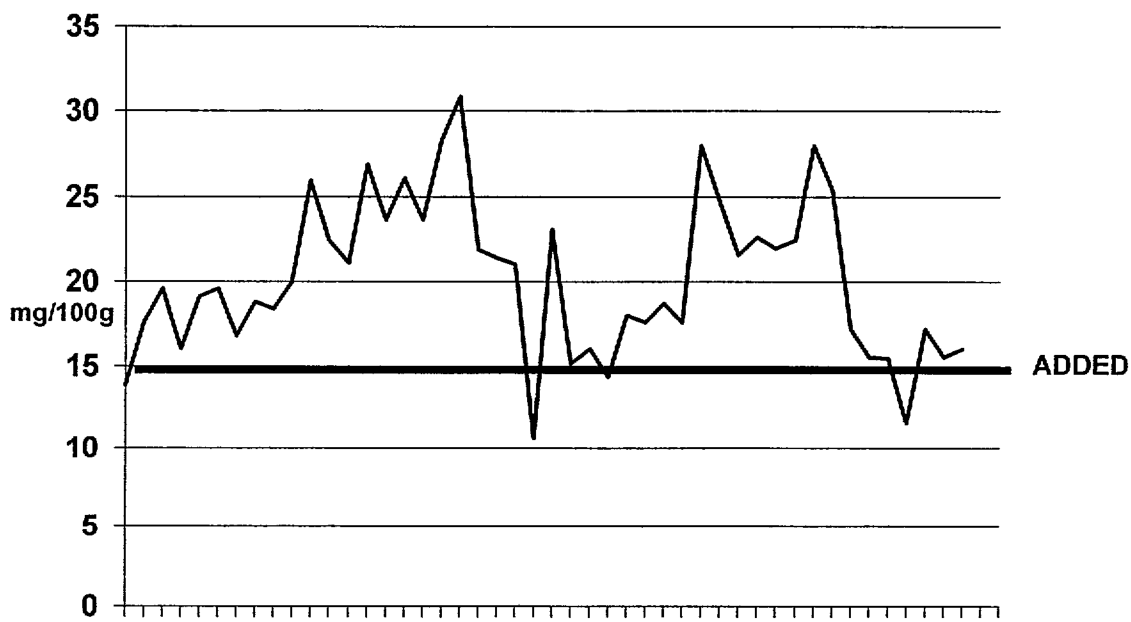


Fig 20 - Iron in CSB at Plant C

Histogram



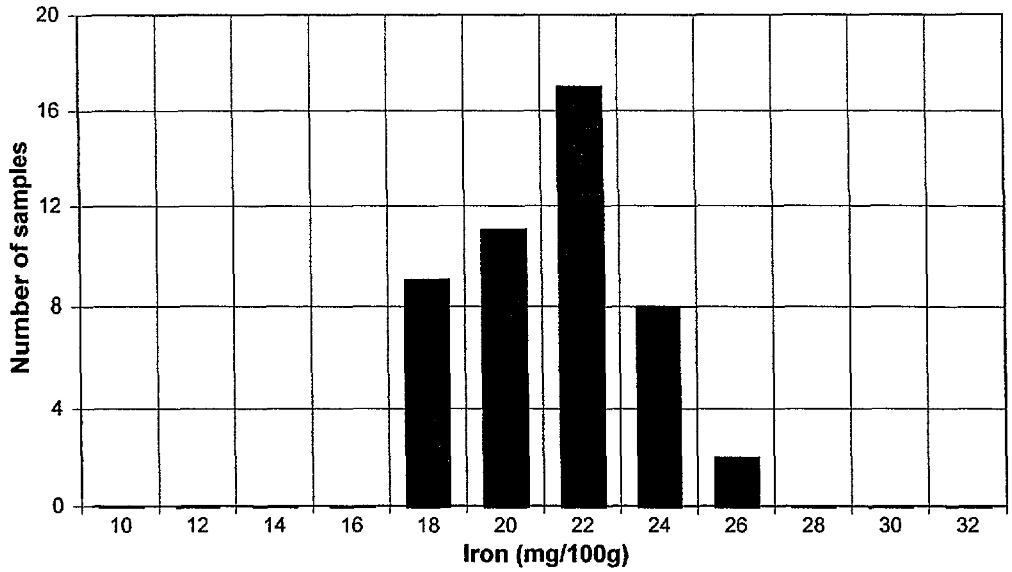
Control Chart



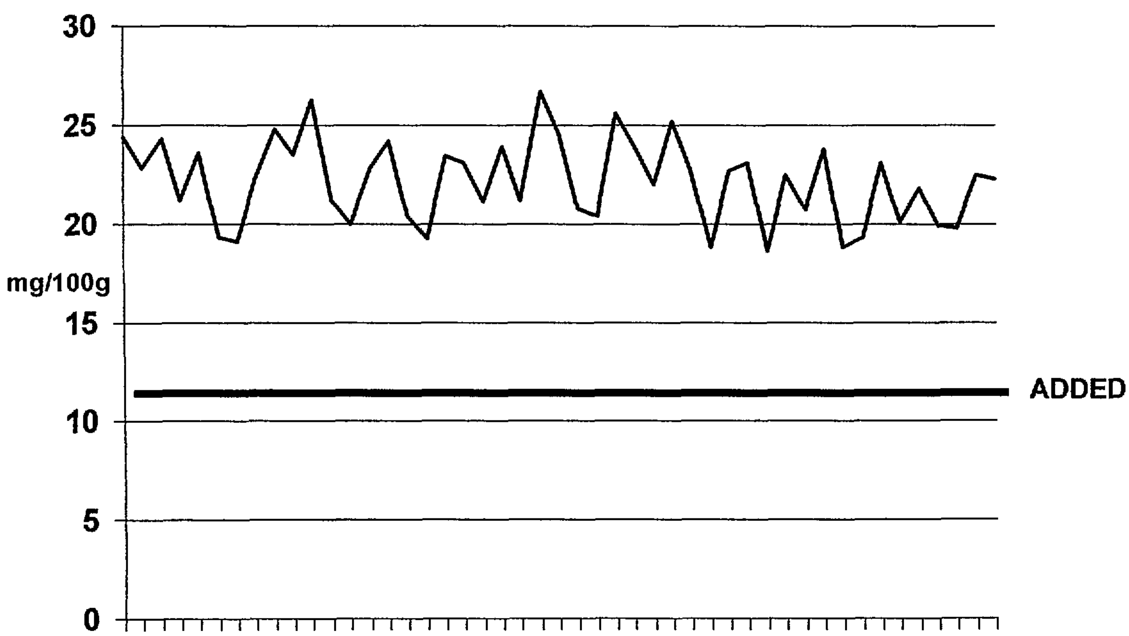
Number of samples 46 Mean Iron 20 2
Standard Deviation 4 6 COV 23%

Fig 21 - Iron in CSB at Plant E

Histogram



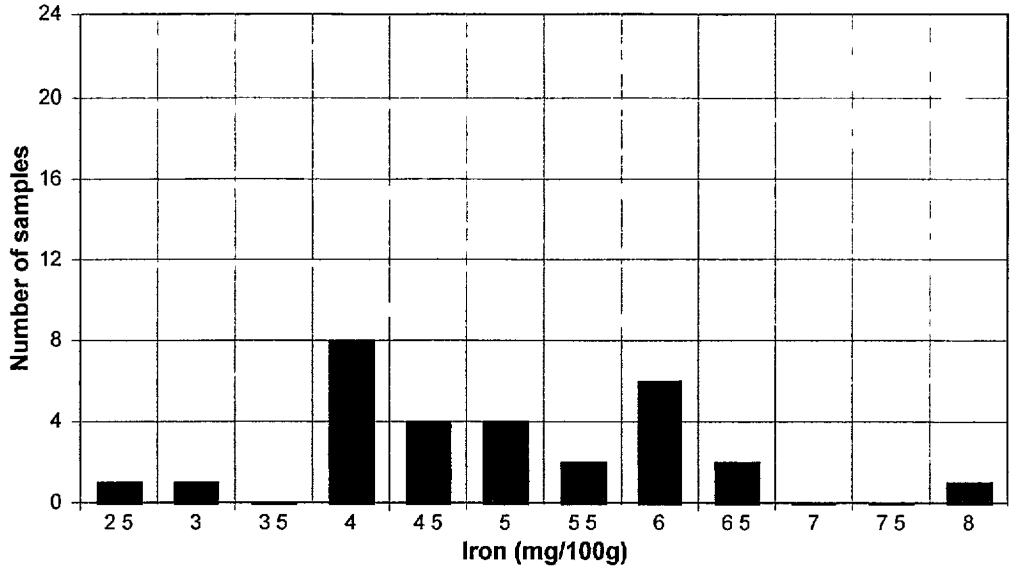
Control Chart



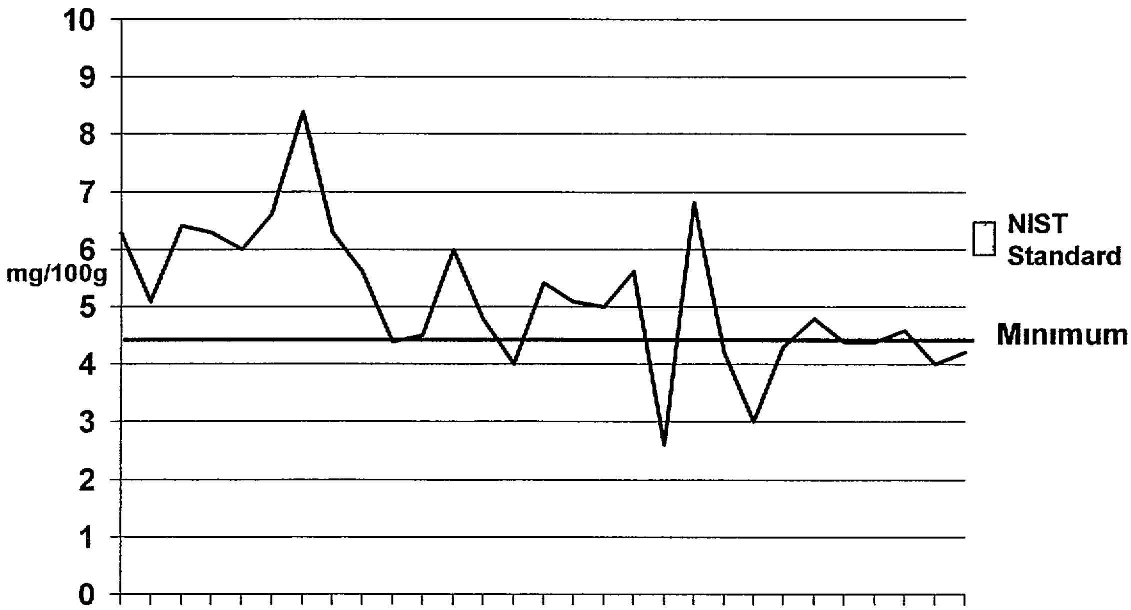
Number of samples 47	Mean Iron 22 2
Standard Deviation 2 1	COV 9%

Fig 22 - Iron in Wheat Flour at Plant F

Histogram



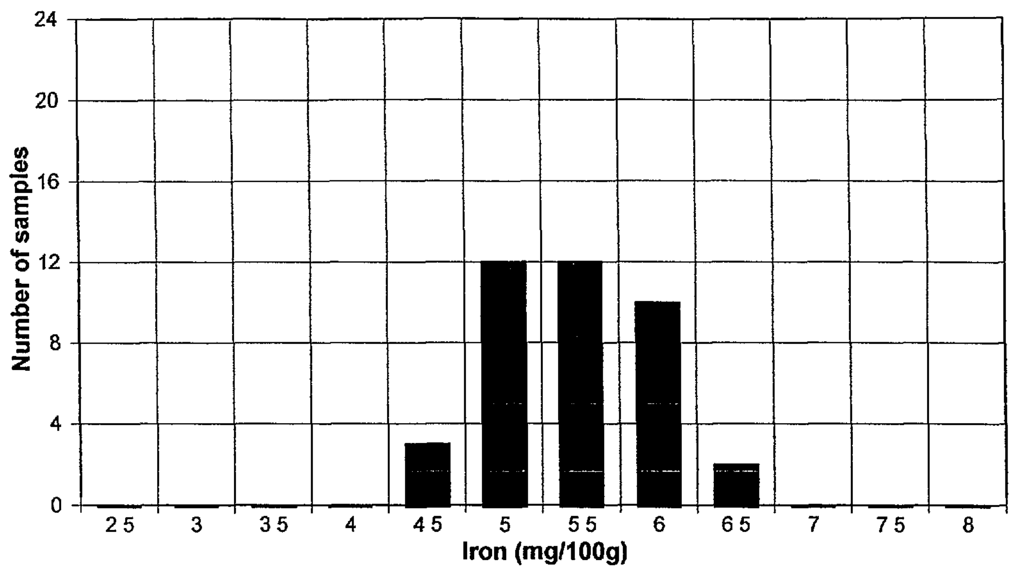
Control Chart



Number of samples 29	Mean 5 14
Standard Deviation 1 20	COV 23%

Fig 23 - Iron in Soy Fortified Bulgur at Plant G

Histogram



Control Chart

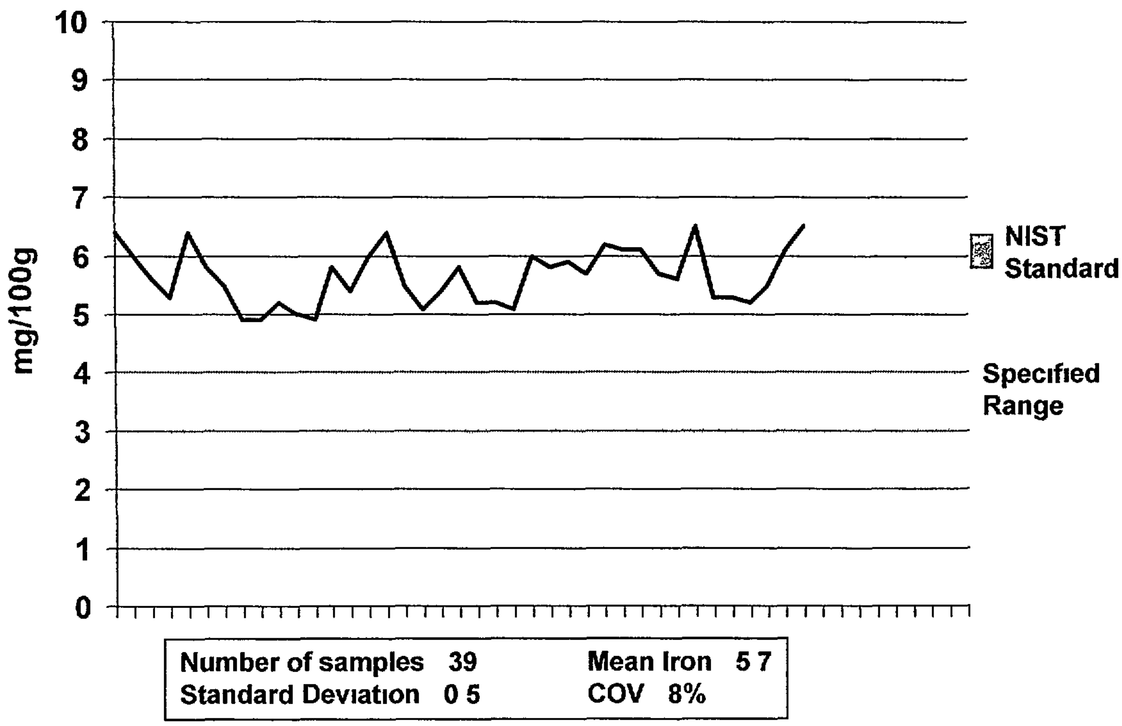
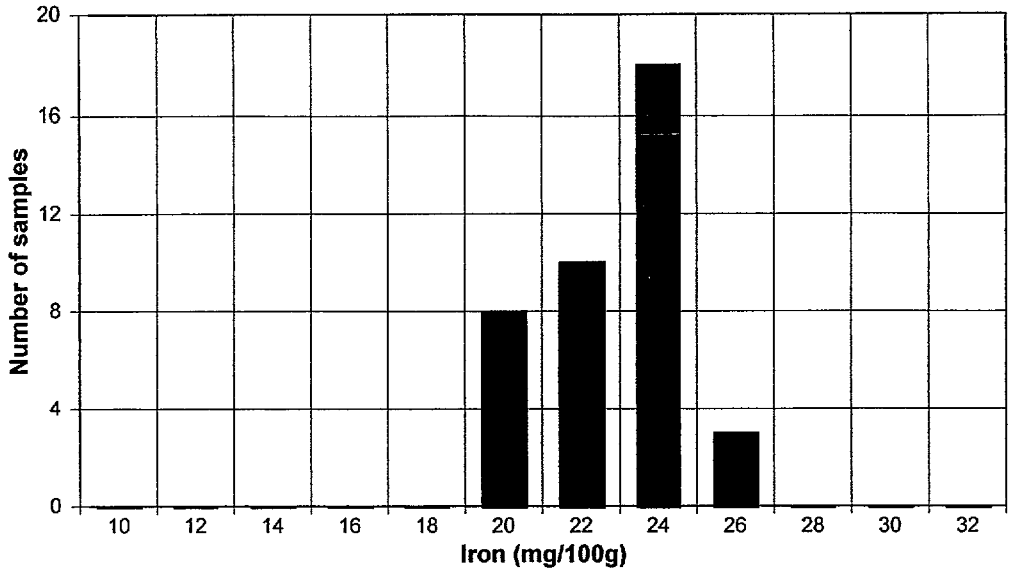


Fig 24 - Iron in CSB at Plant H

Histogram



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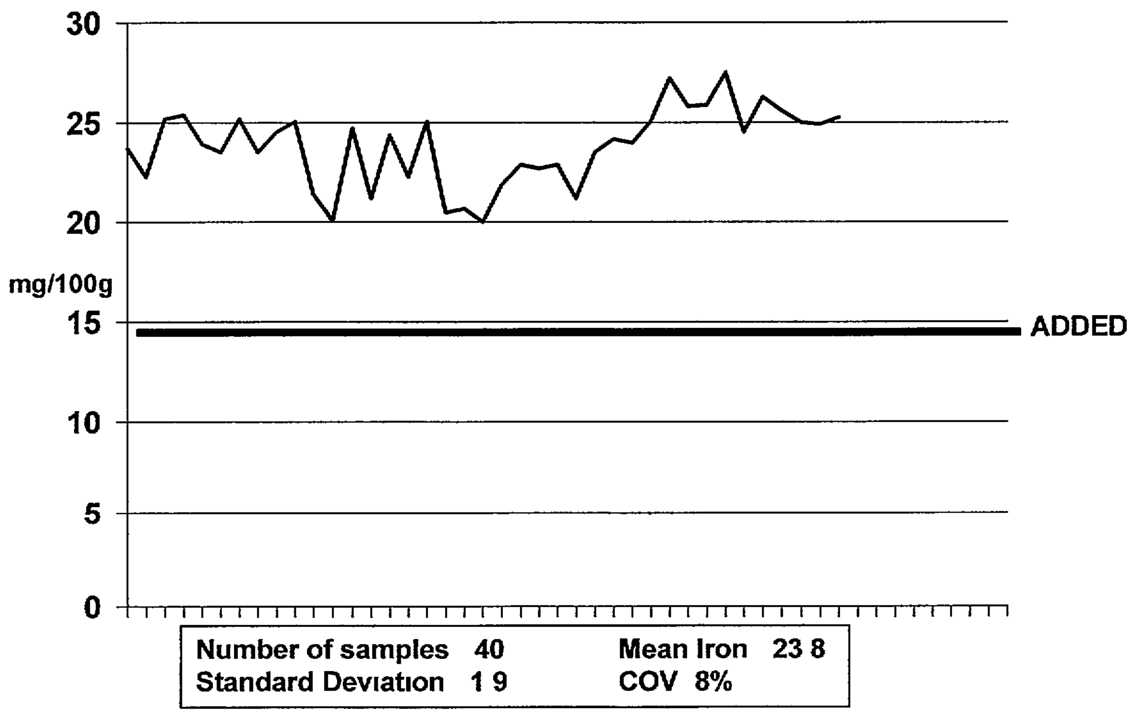

APPENDIX F
Companies Producing Fortified P L 480 Food Commodities and Vitamin/Mineral Premixes

Appendix F
Companies Producing Fortified P L 480, Food Commodities

Archer Daniels Midland (ADM) Milling – Bulgur, SFB, WSB, Wheat Flour, Corn Meal, SFCM, CSB, SFSG

Agricor, Inc – Corn meal

Bartlett Milling Company – Wheat Flour

Bethel Milling – CSB, Corn Meal

Cargill Inc – Wheat Flour

Cereal Food Processors, Inc – SFSG

ConAgra Specialty Products – Corn Meal, CSB, MASA Flour

Didion Milling Inc – Corn Meal, SFCM, CSB

Fisher Mills Inc – Wheat Flour

Harvest States – Wheat Flour

Lauhoff Milling Division of Bunge Corp – Bulgur, SFB, Corn Meal, SFCM, CSB

Premix manufactures

Watson Enrichment products Company

Research Products Inc

ADM Paniplus Company

Mineral Premix Manufacturer

Roland Industries

Appendix G

Composition of Vitamin and Mineral Premixes Used to Fortify Commodities

Composition of Vitamin Premix used in CSB and WSB

For addition at rate of 2 lbs/2000 tons or 0 1%

Ingredient	Amount per 2 lbs	Units
Thiamin Mononitrate	2 50	g
Riboflavin	3 50	g
Pyridoxine Hydrochloride	1 50	g
Niacin	45 00	g
d-Calcium Pantothenate	25 00	g
Folic Acid	1 80	g
Vitamin B-12	36 00	g
Vitamin A Palmitate (stabilized)	21 00	million IU
Vitamin D (stabilized)	1 80	million IU
Vitamin E (Alpha Tocopherol Acetate)	68000 00	IU
Butylated Hydroxyanisole	20 00	g
Butylated Hydroxytoluene	20 00	g
Ascorbic Acid (stabilized, coated)	364 00	g
Corn starch	to make 2 lbs	

Standard Premix for Fortification of PL480 Wheat Flour

For use at addition rate of 0 5 oz/cwt or 313 grams/MT

Ingredient	Concentration in Premix %	Level Added	units
Thiamine	1 9	0 58	mg/100g
Riboflavin	1 3	0 40	mg/100g
Niacin	14 8	4 63	mg/100g
Folic Acid	0 5	0 15	mg/100g
Vitamin A,(250SD) 250,000 IU/g	30 2	2360	IU/100g
Iron, reduced	12 0	3 75	mg/100g
Starch and free-flow agents	Remainder		

Standard Premix for Fortification of PL480 Corn Meal

For use at addition rate of 0 5 oz/cwt or 313 grams/MT

Ingredient	Concentration in Premix, %	Level Added	units
Thiamine	1 3	0 42	mg/100g
Riboflavin	0 9	0 26	mg/100g
Niacin	10 0	3 09	mg/100g
Folic Acid	0 5	0 15	mg/100g
Vitamin A,(250SD) 250,000 IU/g	30 2	2360	IU/100g
Iron, reduced	8 8	2 65	mg/100g
Starch and free-flow agents	remainder		

Standard Premix for Fortification of PL480 Bulgur Wheat

For use at addition rate of 0 5 oz/cwt or 313 grams/MT

Ingredient	Concentration in Premix, %	Level Added	units
Thiamine	1 1	0 33	mg/100g
Riboflavin	0 7	0 22	mg/100g
Folic Acid	0 5	0 15	mg/100g
Vitamin A,(250SD) 250,000 IU/g	30 2	2360	IU/100g
Iron, reduced	3 5	1 09	mg/100g
Starch and free-flow agents	Remainder		

KEY
IU - International Unit
MT- Metric Ton
(SD) - Code for Vitamin A used
cwt - 100 pounds

Appendix H

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APPENDIX I.
Advisory Details on P L 480 Program Foods

APPENDIX I

Background Information on P L 480 Food Aid Commodities

The P L 480 Title II Food Assistance Program

The U S has been providing global food assistance since 1954, when the Agricultural Trade Development and Assistance Act, also known as Public Law 480 (P L 480), was enacted Since that date the USG has distributed some 375 million metric tons valued at over 50 billion dollars The P L 480 food assistance program works through many partners in the U S and abroad, including non-governmental and private voluntary organizations (NGOs and PVOs) and the World Food Programme (WFP) Increasingly, the P L 480 Program is focusing on emergency, transition and development efforts in Sub-Saharan Africa and South Asia, where the majority of the world's 840 million hungry and undernourished people reside

In FY 1997, the entire P L 480 Food Assistance Program (including Title I, Title II and Title III)[1] provided 2 84 million metric tons valued at $1 1 billion to people in 63 developing and re-industrializing countries (*1997 U S International Food Assistance Report*, USAID, January 1998) The commodities used in any given year may vary according to need and availability Those used in FY 1997 are provided in the box to the right USAID manages the bulk of P L 480 food assistance through the emergency and development activities of Title II, the P L 480 food donations instrument In FY 1997, Title II distributed a total of 1 66 million metric tons valued at $821 million to 43 million people in 53 countries Title II became a more tightly focused program with a coherent set of development-oriented food security objectives directed to the most food insecure and disadvantaged population groups USAID improved targeting through need assessments, documenting change in nutritional status of target groups, integrating Title II food aid resources in USAID Mission strategic planning, collaborating with other donors, and establishing measurable performance indicators At the same time, USAID increased its attention to eliminating micronutrient malnutrition, especially vitamin A deficiency

Table 1 Commodities Provided by U S Food Programs, FY 1997

	Thousand Metric Tons
Wheat	1 329
Corn	269
Corn Soy Blend	211
Rice	218
Vegetable Oil	184
Wheat Flour	161
Soybean Meal	108
Bulgur	68
Soy-Fortified Bulgur	60
Sorghum	44
Soy-Fortified Cornmeal	43
Peas	30
Beans	26
Cornmeal	24
Lentils	20
Soy-Fortified Sorghum Grits	14
Soy Beans	10
Wheat Soy Blend	9
Cotton	6
Whole Dry Milk	3
Tallow	2
Corn Soy Masa Flour	1
Nonfat Dry Milk	1
Total	**2,841**

(Source USDA/FAS/11-18-97)

Legislative Mandates

Several aspects of the P L 480 legislation specifically affect Title II, the commodity mix (e g , whether whole grain/unprocessed value-added[2], bagged or bulk) and how commodities are

[1] According to the ***U S International Food Assistance Report 1997(USAID, January 1998) Title I*** provides for the sale of agricultural commodities to developing countries and private entities for long-term concessional dollars credit $245 million was approved for FY 1998 ***Title II*** provides emergency and development assistance in partnership with PVOs NGOs and the WFP $837 million was approved for FY 1998 ***Title III*** provides government-to-government commodity donations to developing countries tied to policy reforms $30 million was approved for FY 1998

[2] Value-added commodities include those that are blended fortified and/or otherwise processed

programmed (e g , in emergency, non-emergency[3], direct distribution or monetization activities), which is relevant to understanding the policy context in which the MAP findings must be interpreted P L 480 legislation includes five *Congressional Mandates*, which are target levels that Title II is supposed to meet each year How these are met in a given year will directly or indirectly determine the quantity of micronutrients available to the program and recipients overseas

In FY 1997, the *Minimum Mandate* was 2 025 million metric tons for total approved metric tons programmed under Title II, with a *Subminimum Mandate* of 1 55 million for non-emergency programs through PVOs, Community Development Organizations (CDO) and the WFP In FY 1997, Title II met 96 % of the minimum and 67 % of the subminimum targets[4] This meant that virtually all the authorized commodities were programmed and because of relatively more emergency activities, emergency and non-emergency programs were funded at approximately the same levels ($404 million each)

The *Value-Added Mandate* stipulates that 75 % of approved non-emergency program commodities be processed, fortified or bagged It is this mandate that most directly affects the amount of micronutrients available through Title II The more processed and blended fortified foods shipped, the more micronutrients will flow to the target populations In FY 1997, the target was almost reached at 73 3 %, with half (51 7 %) being value-added commodities [5] This is a loss to potential micronutrient delivery through Title II of about one-third in one year

The *Monetization Mandate* provides a target of 15 % for the total approved Title II programs that are non-emergency Monetization programs[6] This is considered a floor amount Recent trends, however, including the reduced availability of other USAID dollar funds, have led the Title II cooperating sponsor groups to develop more monetization activities This resulted in the percentage of monetization programs going from what hovered at about 20-25 % to almost 40 % in FY 1997 and over 50 % in FY 1998, according to preliminary USAID estimates[7]

The trend toward increased monetization in FY 1998 appears to have tipped the balance Monetization programs are required to complete a *Bellmon Analysis*, which is a study of the potential effects of importation and sale of the proposed Title II commodity(ies) and the assurance that there will be no disincentive effects from monetization activities Indeed, most monetization programs use bulk (rather than bagged) whole wheat and wheat flour and unrefined crude degummed vegetable oil (usually soybean oil), as these are likely to get the best monetary return when sold on the local market This means that, under the fixed ceiling authorized in the budget allocation process, if more bulk and whole grains are used to fulfill monetization commitments, fewer value-added products will be called for Fortified, monetized Title II food commodities deliver micronutrients to the larger population This is beneficial as micronutrient deficiencies, such as that for vitamin A, affect a significant segment of the population even though only a small percentage may have the visible clinical signs of severe deficiency As with any monetization program, the proceeds are used to provide programs and activities directed at improving the food security and nutrition of the vulnerable target groups

Current Uses of Title II Fortified Commodities

The Title II Program of P L 480 provides food commodities for direct distribution and other mechanisms (e g , food for work, cash for work, monetization) in emergency, transition and development projects

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[3] Non-emergency activities are also called development activities in this report

[4] In FY 1997 the P L 480 tonnage reached 1 947 137 against the ***Minimum*** and 1 039 846 against the ***Subminimum*** mandated targets Metric Ton Grain Equivalent (MTGE) is used to report against target

[5] The preliminary estimates from USAID/BHR/FFP

[6] Monetization assumes that the Title II commodities would be sold for local currency (monetized) in-country for a limited purpose and that the proceeds would be used to cover mainly the administrative/logistic costs related to the in-country transportation warehousing and distribution of Title II commodities

[7] FY 1998 estimates (compiled November 16 1998) reported by USAID/BHR/FFP at the December 3 1998 meeting of the USAID Food Aid Consultative Group (FACG) in Washington D C

Basic guidance for these programs is provided by USAID and updated yearly (e g , Development Activity Proposal [DAP] Guidance for the Year 2000) The composition of the commodities, their uses in project activities and the ration composition under different scenarios are provided in the USAID Commodities Reference Guide (1988) Guidance on emergency, development and transition programs will be available in an updated 1999 Edition (in preparation)

Title II food commodities are inexpensive food staples used to provide basic nourishment to populations experiencing conditions of hunger and extreme food insecurity under emergency activities They are also used for development activities designed to fill a protein calorie gap, attract at-risk target populations to complementary services (e g , Maternal-Child Health) or enhance school attendance or performance (School Feeding and Food-for-Education) P L 480 programs primarily target at-risk women and pre-school age children in the most low-income food deficit (LIFDC) countries Geographic focus is on Sub-Saharan Africa and South-East Asia, where the vast majority of the world's 840 million hungry people reside In most cases, their malnutrition is caused by civil unrest, natural disasters and being displaced from home into refugee situations

Commodity Types

The commodities generally provided under the P L 480 Title II Program fall into two categories The first comprises non-processed foods such as wheat, corn, soybeans, peas, dry beans and lentils The second type of commodity is comprised of processed foods or *value added* foods These are processed foods that are manufactured and fortified to particular specifications for the Title II Program on an as-needed basis This category comprises processed cereals, which are primarily milled cereals, like wheat flour corn meal, rice and bulgur, two fortified blended foods, and vitamin A fortified edible vegetable oil

Non-processed foods are the least expensive of the commodities but require considerable food preparation by recipient institutions or households For example, wheat and corn must be ground prior to cooking or baking Peas, dry beans and lentils have cooking times that depend on their size and age (e g the smaller and fresher, the shorter the cooking time) Longer cooking times require more fuel and water that are often in short supply in refugee and emergency situations Whole grains and pulses are not currently fortified with vitamins and minerals, although it would be possible to apply an extrusion technology to whole grains, similar to the *UltraRice* product used to fortify rice Pulses are naturally high in protein, fiber, iron and B vitamins so they are often used to enhance the ration In combination with grains (e g , wheat, wheat flour, rice, corn, bulgur), they provide a more complete protein of higher quality than does each alone

The processed foods are primarily milled cereals, like wheat flour, corn meal, rice and bulgur Soy-fortified versions of corn meal and bulgur are available They are generally fortified with micronutrients rice being the main exception Corn meal, bulgur and rice are relatively easy to use in local dishes and take less time to cook than the non-processed commodities Wheat flour requires some baking and special equipment such as a mixer and oven, to turn into bread The two fortified blended foods, CSB and WSB, are nutritionally balanced combinations of protein, fat, vitamins and minerals Their composition is shown in Table 3 Fortified blended foods require only five to ten minutes of cooking time They were designed specifically for the P L 480 Program as weaning or complementary foods for children between the ages of 6 and 24 months, however they are used to prepare other dishes consumed by adults (e g , dumplings) as described in the MAP study

Refined vegetable oil is provided in feeding and monetization programs It can come from soybeans sunflowers other oils or provided as a mixture Soybean oil has been used in recent years almost exclusively, however It is used either as a medium for frying or as an ingredient in dishes Because of its high caloric density (884 kcal/100g) compared to the other commodities (~ 350 kcal/100g) it is generally used as the energy source for the ration It is available also as crude, degummed, soybean oil (CDSO) which is purchased in bulk for use in monetization programs to be refined on the local market Oil is a good vehicle for vitamin A fortification (because vitamin A is naturally a fat-soluble compound) and as a result of a MAP vitamin A fortification of oil feasibility study (Bagriansky and Ranum, 1998) USAID and USDA now require that all refined vegetable oil be available to the Title II program only as vitamin A-fortified (USDA Announcement VO7, December 1, 1998, see Appendix D8)

Composition and Specifications

The USDA sets the specifications for the fortified food commodities used in the P L 480 Title II Program in periodic Announcements The wheat flour and corn meal products used in P L 480 are fairly standard products, similar in composition to those found in the U S market Bulgur is made by cooking cleaned, tempered whole wheat until it becomes gelatinized It is then cooled and partially ground Defatted, toasted soy flour is added to the soy-fortified versions at a level of 15% to boost protein content and quality as the amino acid content of soy is nutritionally complementary to those of wheat and corn

CSB consists of partially gelatinized, ground corn meal and defatted, toasted soy flour combined with soybean oil, vitamins and minerals WSB contains flour ground from bulgur combined with soy flour, oil, vitamins, minerals and a wheat protein concentrate (WPC), which is basically the high protein milling faction called "red dog" that has been heated to reduce enzyme activity Another formulation for WSB without bulgur is allowed but was not being produced during the course of this study so it is not discussed in the report CSB and WSB are made with the same vitamin premix and mineral premix formulations, shown in Appendix G USDA specifications stipulate that these two premixes musts be kept separate prior to blending into the product

Table 2 P L 480 Title II Fortified Foods

Commodity Cost	Quantity Provided During FY 1997 (1 000 Metric Tons)	Average Cost[8] ($/MT)	Value (Million $)
Corn Soy Blend (CSB)	211	335	70 7
Wheat Flour	161	305	49 1
Bulgur	68	258	17 5
Bulgur Soy Fortified	60	276	16 6
Corn Meal, Soy Fortified	43	310	13 3
Corn Meal	24	311	7 5
Sorghum Grits, Soy Fortified	14	304	4 3
Wheat Soy Blend (WSB)	9	458	4 1
Totals	590		183 1

Table 3 Composition of CSB and WSB by Weight Percentage

Ingredient	Corn Soy Blend		Wheat Soy Blend[9]	
	By weight	by cost	By weight	by cost
Corn meal, processed	69 6 %		-----	
Soy flour, defatted, toasted	21 8 %		20 0 %	
Bulgur flour	-----		52 9 %	
Wheat Protein Concentrate	-----		20 0 %	
Soybean oil	5 5 %		4 0 %	
Vitamin premix[10]	0 1 %	4 6 %	0 1 %	3 4 %
Tricalcium phosphate	2 0 %	7 2 %	2 0 %	5 2 %
Salt/Mineral premix	1 0 %	2 5 %	1 0 %	1 8 %

Nutritional Content

The final nutritional content in Title II fortified foods, given in Table 4, is the levels of nutrients added plus what is naturally present The values shown in Table 4 are those that should be used in calculating dietary intakes and ration size Values are derived either from the specifications of the commodity (e g , from

[8] Average delivered cost including freight

[9] There is an alternative formulation allowing 38 1% straight grade flour in place of the bulgur flour and 35% wheat protein concentrate but that formulation was not being used during this study

[10] See Appendix G for composition of premixes

USDA specifications), as with protein and added micronutrients, or calculated from the nutritional content of the base foods as given by the USDA Food Composition Tables[11]

Table 4 Nutritional Composition of PL480 Commodities (per 100g)
(Source 1989 CRG Food Commodity Fact Sheets)

Nutrient	Unit	Bulgur Wheat BW	Corn Meal CM	Corn Soy Blend CSB	Rice Rice	Soy Fort Bulgur Wheat SFBW	oy Fort Corn Meal SFCM	Soy Fort Sorghum Grits SFSG	Sorghum Grits SG	Veg Oil Vegoil	Wheat Flour WF	Wheat Soy Blend WSB
Water	g	9	12	10	12	9	11	9	9	0	12	9
Energy	Kcal	342	366	374	365	340	360	337	339	884	364	354
Protein	g	12	8	17	7	18	15	17	11	0	10	21
Total Lipid	g	1	2	7	1	1	2	3	3	100	1	6
Carbohydrate	g	76	78	61	80	70	71	69	75	0	76	47
Fiber, total dietary	g	18	7	9	1	18	9	n/a	n/a	0	3	13
Ash	g	2	1	2	1	2	1	2	2	0	0	2
Calcium	mg	110	110	831	28	110	110	110	110	0	110	842
Iron	mg	3	3	17	1	3	3	3	3	0	4	18
Magnesium	mg	164	40	174	25	183	78	n/a	n/a	0	22	227
Phosphorus	mg	300	84	610	115	356	173	345	287	0	108	760
Potassium	mg	410	162	632	115	706	495	655	350	0	107	694
Sodium	mg	17	3	7	5	17	6	8	6	0	2	14
Zinc	mg	1 9	0 7	5 0	1 1	2 0	1 0	n/a	n/a	0 0	0 7	5 5
Copper	mg	0 3	0 1	0 9	0 2	0 9	0 7	n/a	n/a	0 0	0 1	1 0
Manganese	mg	3 0	0 1	0 7	1 1	3 0	0 5	n/a	n/a	n/a	0 7	2 2
Selenium	mcg	2 3	7 8	5 8	15 1	2 2	6 9	n/a	n/a	0 0	33 9	1 6
Vitamin C	mg	0	0	40	0	0	0	0	0	0	0	40
Thiamin	mg	0 4	0 4	0 5	0 1	0 4	0 4	0 4	0 4	0 0	0 6	0 5
Riboflavin	mg	0 3	0 3	0 5	0 0	0 3	0 3	0 3	0 3	0 0	0 4	0 5
Niacin	mg	3 5	3 5	6 2	1 6	3 5	3 5	3 5	3 5	0 0	5 3	8 2
Pantothenic acid	mg	1 0	0 3	3 4	1 0	1 2	0 6	n/a	n/a	0 0	0 4	3 7
Vitamin B-6	mg	0 3	0 3	0 3	0 2	0 4	0 3	n/a	n/a	0 0	0 0	0 3
Folate	mcg	150	150	300	8	150	150	150	150	0	150	275
Vitamin B-12	mcg	0 0	0 0	1 3	0 0	0 0	0 0	0 0	0 0	0 0	0 0	1 3
Vitamin A	IU	2205	2205	2611	0	2205	2205	2205	2205	6000	2205	2323
Vitamin E	ATE*	0 2	0 3	8 7	0 1	0 1	0 3	0 0	0 0	18 2	0 1	8 3
Vitamin D	IU	n/a	n/a	198	n/a	n/a	n/a	n/a	n/a	n/a	n/a	198
Iodine	mcg	n/a	n/a	57	n/a	n/a	n/a	n/a	n/a	n/a	n/a	57
Pyridoxine HCL	mg	n/a	n/a	0 2	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0 2

*mg alpha tocopherol Equivalents
n/a information not available

Specifications and Quality Control

The composition, packaging and analytical specifications for each P L 480 food commodity are given in a series of Announcements prepared by the Kansas City Commodity Office (KCCO) of the USDA, Consolidated Farm Service Agency (FSA) which is responsible for the procurement of these and all commodities under the P L 480 Program (Titles I II and III) They are regularly updated as specifications change In certain cases monetary penalties or *quality discounts* are assessed for product falling outside specific limits Discounts (given in cents per 100 pounds reduction in the purchase price) are normally applied for deviations in moisture, fat and granulation content The USDA can enforce compliance by rejecting lots that fail to meet specifications or by disqualifying a producer from bidding on future contracts

[11] Handbook 8 1997 version Drake 1989

Until recently, micronutrient testing of fortified P L 480 commodities was not routinely performed and there has been little enforcement of the fortification standards in the final product As a result of MAP activities and preliminary findings, USDA has begun micronutrient testing and will be enforcing fortification standard specifications There are several ways that these procedures can be enhanced For instance, USDA inspectors must be present at the production plant when production is running and are generally aware of whether or not the vitamin/mineral premix feeders are operating They also can check invoice records to confirm that the manufacturer has been purchasing the premix In the case of one CSB producer, discrepancies in premix usage, along with other violations, led to that company being disqualified from the P L 480 Program in 1996 It has since been recertified under different ownership

Current quality control procedures used for P L 480 food commodities, as for any other U S Government purchased food, consists of on-site inspection and sampling followed by analysis of the samples at the Kansas City, Federal Grain Inspection Service (FGIS) Laboratory to determine whether it met specifications and whether any quality discounts will be applied Because of the cost and limited effectiveness of this traditional end-item inspection method, the USDA is exploring a different system, one that is more in line with the total quality programs used by the U S food industry The proposed Total Quality Systems Audit (TQSA) focuses on the quality of the manufacturing process, rather than the finished product characteristics TQSA places responsibility on the producers themselves to prove they have the capability of continually and consistently producing a quality product Many of the P L 480 commodity producers routinely operate under this type of program for products they manufacture for customers other than the U S Government indicating that they are familiar with such procedures This process will help bring the standards of production of food commodities for Title II up to par with those for processed foods manufactured for the general U S population thereby reducing the potential for a double standard

The USDA notice requiring the fortification of vegoil with vitamin A (Appendix D 8) stated that vendors should have sufficient quality control measures to ensure the proper addition and homogeneity of the vitamin in the oil USDA stated that while inspection of this fortification would be performed by the FGIS laboratory, to expedite shipments and reduce government testing contractors were authorized to utilize the services of a private independently owned and operated laboratory capable of performing the analytical test for vitamin A content in oil

Micronutrient Fortification

Rationale for Fortification

The first objective of a food aid program is to provide *macronutrients* (carbohydrates, protein and fat) in the form of culturally acceptable, inexpensive foods to complement the local food basket, in order to fulfill energy and protein requirements of the target population Cereals (wheat and corn), in combination with pulses (dry beans, peas and lentils), provide a more complete protein than either one alone These are the most cost-effective and acceptable foods for this purpose Fortification of cereal staples with soy flour increases the protein content and quality of the cereals, which are not naturally rich in protein

Once basic energy and protein requirements are satisfied, attention is directed at providing adequate levels of *micronutrients* - vitamins and minerals The foods provided under P L 480 naturally contain most, but not all, of the vitamins and minerals needed to maintain health Vitamin A is available from liver and other organ meats and can be derived from the beta carotene in orange/red fruits and vegetables and in dark green, leafy vegetables Cereals do not naturally contain vitamin A and they have low levels of beta carotene Other nutrients like calcium, are at very low levels in cereals Also, the levels of many of the micronutrients are drastically lowered from their whole grain levels when milled into wheat flour and corn meal

Iron presents a special problem in that the level of iron is not only low in milled cereals but also the iron that is present is not very bioavailable when the diet consists largely of cereals with little or no animal food sources, as is generally the case in refugee camps and low income situations Fortification of processed foods with certain vitamins and minerals is the only way to insure adequate micronutrient intakes in these vulnerable groups

USAID, recognizing the critical need for more vitamin A in the diet of food aid recipients, requires that vitamin A be included in the fortification of processed foods Other micronutrients (e g , thiamin, riboflavin, niacin, folic acid and iron) are required to make the commodity compliant with the U S enrichment standards applied to the general food supply Title I commodities are generally not fortified, because they tend to be whole grains and other commodities provided under concessional loan conditions from the U S government to the host country government, in contrast to the Title II Program which is intended to improve the nutrition and food security of its participants Rice is an exception which is not enriched to U S standards because of the high cost, perceived technical difficulties, appearance changes and loss of nutrients during rinsing that is typical in the preparation of rice in most of situations where Title II foods are consumed

Fortification of Processed Cereals

All processed food provided under Title II programs, with the exception of rice, are required to meet the U S standards for enriched cereals, meaning that they must be fortified with B vitamins (thiamin, riboflavin, folic acid and niacin) and iron USDA policy requires that any changes made in the U S enrichment standards for foods with a U S Standard of Identity automatically be applied to the same foods used in the Title II Food for Peace (FFP) program The inclusion of folic acid to the U S Standard of Identity for enriched cereals is a recent example that was applied to the same commodities in the P L 480 Title II Program as of January 1, 1998

Table 5 Micronutrient Standards[12] for Fortified P L 480 Processed Foods

Commodity	Thiamin (mg/100g)	Ribo-flavin (mg/100g)	Folic Acid (mg/100g)	Niacin (mg/100g)	Vitamin A (IU/100g)	Iron (mg/100g)	Calcium (mg/100g)
Wheat Flour and Soy Fortified Flour	0 64	0 40	0 15	5 29	2205-2644	4 41	110
Corn Meal Soy Fortified Meal Corn Flour and Masa Flour	0 44 - 0 66	0 26 - 0 40	0 15 - 0 22	3 53 - 5 29	2205 - 2644	2 86 – 4 41	110 - 138
Bulgur and Soy Fortified Bulgur	0 44 - 0 66	0 26 - 0 40	0 15 - 0 22	3 53 - 5 29	2205 - 2644	2 86 – 4 41	110 - 138

In addition to the standard enrichment, all Title II processed foods are required to be fortified with vitamin A because of the great need for this vitamin by most populations targeted for food aid Historically, the U S cereal enrichment program has added only those nutrients that are naturally present in the cereal, reduced significantly in concentration by the milling process, and deficient in the diet of the general population Vitamin A does not meet these criteria since it is not naturally present in cereals There is also far fewer cases of vitamin A deficiency in the United States than there are in most developing countries so it is not required as an enrichment in U S milled products Folate was added to the U S enrichment standards just recently

The addition of calcium is optional under the U S enrichment standards While some producers add calcium, most do not The source of calcium used is either calcium carbonate or calcium sulfate Tricalcium phosphate is never used to increase calcium levels by the U S cereal industry, although it may be added at low levels for other purposes Whether calcium should be made mandatory has been an issue of debate for some time Reasons why it remains optional are that wheat is not a particularly good source of this mineral and its levels are not reduced much by milling

The micronutrient standards for fortified processed foods shown in Table 5 are the same used under U S Food and Drug regulations for these foods, with the additional requirement of vitamin A and calcium They are given as a minimum with overages left to good manufacturing practices for wheat flour or as a minimum-maximum range with the others, the same as required under U S standards for enriched cereal

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[12] Single values indicate a minimum with overages left to good manufacturing practices Two values separated by a dash (-) indicate a minimum - maximum allowable range

foods Vitamin A, however, is always given as a range There is no U S standard for enriched bulgur wheat, so the standards for bulgur were based on those existing for wheat flour at the time bulgur was developed as a P L 480 commodity The standards for wheat flour were subsequently increased to the higher values shown in Table 5, but bulgur remained at the old levels

The levels of micronutrients to be added to meet U S enrichment standards for processed foods for general consumption and the Title II Program are determined specifically to make up for the difference between the standard and the natural level of the nutrient in the un-enriched food plus a reasonable overage to ensure that the standard will be met Since there is no vitamin A naturally present in any of these commodities its addition rate is the standard plus an overage Because bulgur is nearly a whole wheat product it contains high natural levels of iron and the B vitamins The levels of these micronutrients added to bulgur, therefore, are lower than what is added to cornmeal following the same standards

Fortification of Vegetable Oil

Until recently the vegetable oil (vegoil) provided under P L 480 as not fortified Following a MAP activity and report by SUSTAIN on the feasibility and desirability of adding vitamin A to vegoil used in the Title II Program, USAID requested USDA that vegoil be fortified with vitamin A as of December 1, 199 (Appendix D 8) The form of vitamin A added is retinol palmitate at a level of 60 IU/g minimum to 75 IU/g maximum

Fortification of the Blended Foods (CSB and WSB)

The micronutrient fortification for the two blended foods (CSB and WSB) is shown in Table 6 The table shows the change in the fortification design instituted in 1998 by the USDA reflecting current thinking on dietary requirements This involved inclusion of magnesium, an increase in zinc levels and a decrease in vitamin B12 Also shown are the current fortification standards for CSB type products manufactured for the World Food Programme Some of the U S manufacturers making CSB for USAID also produce it for the World Food Programme (WFP), the main difference being the composition of the vitamin and mineral premixes WFP requires a much lower level of calcium than that used in CSB while other nutrients, except for vitamin C and zinc, are generally lower Other micronutrients, notably magnesium, are not added at all

USDA regulations specify the composition of the vitamin and mineral premixes to fortify CSB and WSB, as shown in Appendix G The same composition is used for both commodities In contrast to the processed foods, the values shown in Table 4 for the blended foods are *target levels* added and not necessarily the *final levels* in the product, although many groups have used them, incorrectly, in that manner There are no final product specifications for blended commodities and there is currently no testing of the commodities for final micronutrient content to insure that they have been properly fortified

Table 6 Micronutrient Addition Level Standards for Fortified Blended Foods

Micronutrient	units per 100g	CSB/WSB Levels Added prior to Jan 98	CSB/WSB Levels Added after Jan 98	World Food Programme CSB
Calcium	mg	775	775	100
Calcium d Pantothenate	mg	2 76	2 76	
Folic acid	mg	0 20	0 20	0 06
Iodine	µg	45	57	
Iron	mg	14 7	14 7	8
Magnesium	mg	0	82 5	
Niacin	mg	4 96	4 96	4 8
Pyridoxine HCl	mg	0 17	0 17	
Riboflavin	mg	0 39	0 39	0 45
Salt	g	0 65	0 81	
Thiamin	mg	0 28	0 28	0 13
Vitamin A	IU	2 315	2 315	1 664
Vitamin B12	µg	3 97	1 32	1 2
Vitamin C	mg	40 1	40 1	48
Vitamin D	IU	198	198	100

Vitamin E	IU	7 5	7 5	
Zinc	mg	0 91	3 98	5

Micronutrient Sources and Premixes

Whereas vitamins are found naturally in foods, all the vitamins added to P L 480 commodities are either chemically synthesized or produced by a fermentation process Naturally occurring vitamins often exist in a number of different chemical forms, which differ in their stability, folates and vitamin E being prime examples There are only one or two chemical forms of each vitamin commercially available for use in fortification These are typically the most stable of the different vitamin forms present in foods For example, folic acid is always used as the source of folate, thiamin mononitrate as the source of vitamin B1 and alpha-tocopherol acetate as the source of vitamin E Added vitamins often have better stability than the naturally occurring forms The minerals added to P L 480 foods are normally produced by a chemical process, with the exception of calcium carbonate which is mined from the ground in a very pure form The mineral is generally a salt (ferrous fumarate, zinc sulfate) but the elemental form of iron (reduced iron) is always used in the P L 480 fortified processed foods This is because reduced iron does not promote oxidative rancidity in the commodities, as might occur with other iron sources, giving them a longer shelf-life Rather than add each micronutrient separately, most are added as a single "premix" in the case of processed foods, or as separate vitamin and mineral premixes for blended foods, as specified by USDA regulations The premixes are produced by a handful of companies (listed in Appendix F) that specialize in this type of product These companies have good facilities for blending micronutrients and testing them in the final premix Because of their high concentration in the premix, the analytical methods used are often quite different than those used by USDA to assess them in fortified foods Calcium is normally added separately from the other minerals because of the large quantity involved and because it is less expensive to purchase it in bulk rather than as a component of a premix Calcium carbonate is the form normally used for the fortified processed foods, while tricalcium phosphate (TCP) is required for use in the blended foods

Micronutrient Stability

Vitamins are organic compounds They can be chemically converted to other compounds that do not possess vitamin activity in the human body Conditions that influence the stability of added vitamins include temperature, moisture content, exposure to light, the pH (the acid-base level) of the system and the presence of trace elements, oxidizing agents, reducing agents or enzymes Of the different vitamins added to CSB and WSB, vitamin C, vitamin E and vitamin A are the most labile and likely to be converted to an inactive form Of those added to processed foods, only vitamin A is likely to be lost during dry storage A literature review on the stability of vitamin A and vitamin C in cereals and vitamin A in vegetable oil is provided in Appendix A

Vitamin activity can be lost in storage of the dry commodity, during preparation or cooking of the commodity into the food that is actually consumed, and during storage of the prepared food Thus vitamin A added to wheat flour can decrease (if exposed to light) during storage and shipment of the wheat flour in the baking process and during storage of the baked bread With Title II commodities, foods are normally consumed quickly after preparation, so it was not deemed necessary to study the loss of vitamins in the stored prepared food and is not reported here

Minerals, on the other hand, do not undergo chemical change during storage of the dry commodity There may be some chemical change in the form of the mineral during food processing that could affect its availability to the body, such as the *reduced* or *elemental* iron added to wheat flour becoming soluble and forming a salt during bread fermentation Such changes are poorly understood and probably only important with respect to iron There is no stability problem with minerals, as there is with vitamins since they can not be lost due to chemical reactions Both minerals and vitamins can be lost from food by physical separation This type of loss can only occur during the manufacture and packaging of the commodity, not during storage or food preparation

Micronutrient Costs

Table 7 shows the 1998 cost of the ingredients required for fortifying CSB and WSB in dollars per Metric Ton (MT) of the commodity purchased Vitamins are added as a single premix which costs $15 40 per MT or about 4 6% of the cost value of CSB Of the eleven vitamins in the premix, vitamins A, C and E account for 84% of the vitamin premix cost

Minerals and salt are generally added as a separate premix The cost of this mineral premix increased in 1998 due to the inclusion of magnesium and an increase in the level of zinc The current expense of adding the salt mix is $8 44 per MT of CSB or WSB, but this may change depending on the price of magnesium sulfate Calcium is added separately as tricalcium phosphate (TCP) It is the most costly of the nutrients, accounting for 50% of the total fortification expense

Table 7 Expense of Vitamins and Minerals Added to CSB and WSB

Ingredient	1998 Estimated Cost[13] $/MT CSB/WSB
Vitamins	
Folic Acid	0 12
Niacin	0 35
Pantothenic Acid	0 91
Pyridoxine	0 05
Riboflavin	0 19
Thiamin	0 06
Vitamin A	4 50
Vitamin B12	0 06
Vitamin C	4 20
Vitamin D	0 70
Vitamin E	4 25
Total vitamins	**$15 40**
Minerals	
Ferrous Fumarate	1 65
Magnesium Sulfate	4 54
Salt (Sodium Chloride)	1 95
Zinc Sulfate	0 30
Tricalcium Phosphate	24 00
Total minerals	**$32 44**
Total	**$ 47 84**

The total ingredient expense of fortifying CSB and WSB is estimated at $47 84 per MT of commodity or about 14 3% of the cost value of CSB That amounted to ten million dollars for FY97 purchases, half of which was on the tricalcium phosphate The ingredient expense for fortifying the processed foods is less The vitamin premix expense for wheat flour is $7 10 per MT of flour, with 84% of that due to vitamin A Flour is also fortified with calcium carbonate, which costs about $0 18/kg vs $1 20/kg for TCP An addition of 2 75 kg of calcium carbonate per MT of flour is needed to meet the calcium standards That would give an calcium ingredient expense of $0 50 per MT of flour This is much lower than the cost of fortifying CSB with calcium, not only because the amount of calcium added is lower by one-seventh, but also because the cost of calcium carbonate is about one-sixth that of tricalcium phosphate

The average ingredient expense of adding vitamin A to all fortified P L 480 commodities is about $6 00 per MT of commodity The 590,000 MT of fortified commodities provided in FY97 thus contained about 3 5 million dollars worth of added vitamin A

[13] Fortification cost estimates in $ per MT of fortified commodity are based on the cost of the vitamin/iron premix cost only and do not include associated labor equipment or QC expenses

Vitamin A

The type of vitamin A used to fortify processed and blended P L 480 commodities is a special diluted, protected form, often referred to as 250SD, in which tiny droplets of the liquid vitamin are encased in a dry edible coating The USDA regulations read

> "Vitamin A Palmitate (stabilized) must be added in encapsulated form containing 250,000 IU Vitamin A Palmitate 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 45° C in a sealed container at a level of 10,000 to 12,000 IU per pound in cornmeal having a moisture content in the range of 13 5 to 14 5 percent "

Most commercial sources of vitamin A include antioxidants (BHT, BHA or tocopherols) to prevent them for oxidizing, which destroys their vitamin activity There are two primary commercial producers of vitamin A The Hoffman-LaRoche Company and BASF

Vitamin C

Vitamin C, or L-ascorbic acid, is added only to CSB and WSB at levels of 40 mg/100g The form used is a "stabilized" product having a 2 5% ethyl cellulose coating to provide some protection from oxidation Different types of protective coating of ascorbic acid are available as are new, heat stable forms that can better withstand cooking losses These were discussed in the report on the Vitamin C Pilot Project[14]

Ascorbic acid is a highly water soluble compound and strong reducing agent It is required for the hydroxylation of proline and lysine in collagen synthesis Severe vitamin C deficiency may result in *scurvy*, a disease affecting many body tissues Unlike most mammals, humans cannot synthesize vitamin C because they lack the enzyme gulonolactone oxidase Thus, ascorbic acid must be supplied by the diet Foods rich in vitamin C include fruits and vegetables such as citrus fruits, cantaloupes, strawberries tomatoes and green peppers Potatoes are low in vitamin C but become a good source when eaten in quantity as in many low-income populations Cereal and dairy products, meat, poultry and eggs are poor sources of vitamin C L-ascorbic acid is sometimes added to certain foods to improve quality For example, vitamin C may be added to wheat flour to increase loaf volume in bread Vitamin C promotes iron absorption

Production, Shipping and Storage of Commodities

Production Plants

P L 480 requires all commodities be made in the United States from domestically grown or manufactured ingredients There are a number of plants producing fortified P L 480 cereal based commodities all of which are in the Midwest United States A list of the companies operating these plants is supplied in Appendix F (All of the individual plants mentioned in this report are referred to by a letter only and are not identified by name in order to keep their confidentiality) Some of these plants are owned and operated by large, global food processing companies with multiple plant locations Others are small business operations with a single plant All of the plants visited in this study have laboratories next to the plant and routinely run tests on important properties, such as fat protein, particle size and viscosity Some plants will run tests every hour of production The results of these tests are used internally to insure the product meets critical specifications and are not normally supplied to the FGIS or other outside agencies Only one plant (G) visited in this study routinely ran quantitative tests for micronutrients (vitamin A) Plant C ran semi-quantitative or spot tests for iron in their products

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[14] Ranum P M Chome F Results Report on the Vitamin C Pilot Program Washington DC SUSTAIN 1998

Call Forwards, Contracts and Lots

The USAID Food for Peace office manages the Title II program They approve of the many requests for foods from PVOs, WFP and other donor agencies around the world Each month they request the USDA to obtain quantities of different commodities Requests for production bids are put out as a "call forward each month for the different commodity This specifies the quantity port to which it is to be shipped and when it is required

The different qualified producers then bid on the contract The lowest bidder who is awarded the contract will then have the appropriate bags printed with the contract number For processed and blended foods this is a five digit number preceded by the letters "VEPD"[15] In some cases contracts are split between different plants when production capacity is saturated or to otherwise meet call-forward schedules, but they usually represent a one to three week run for a single plant

Contracts are made up of different lots A lot is normally one to three railcars Most plants pack off two to three lots per day Lots are given consecutive numbers that are often, but not always, printed on each bag The numbering system used varies and with each plant

FGIS Sampling and Quality Control

At the time of this study, the Federal Grain Inspection Service (FGIS), now called the Grain Inspection and Stockyard Agency (GISA), routinely took samples of all fortified P L 480 commodities as they were being produced An official government inspector had to be working in the plant in order for the commodity to be produced The inspector had a number of duties including the inspection of rail cars and checking the weight of the bags One duty was to prepare an official FGIS sample for each lot To do this the inspector would take a sample from the top of the bag just after it was filled and right before it was sealed These samples would be mixed to obtain a single sample weighting roughly one pound The sample was put in a polyethylene bag which was tightly sealed and placed in a cardboard box The box would be labeled and sent to the FGIS laboratory in Kansas City for testing typically within a day after production An important consideration in the FGIS quality control testing is that the cost of the tests are passed back to the producer and are reflected in their cost of production

The number of individual samples that make up the final lot sample depends on the size of the lot If a lot is one railcar 20 samples are collected For two railcar lots, 18 samples are collected for each railcar giving a total of 36 samples making up the lot sample If three railcars make up a lot, 12 samples are collected per car giving 36 samples making up the final lot sample If four railcars make up a lot, 8 samples are collected per car giving 32 samples making up the lot samples Each railcar contains about 2500 bags, but this may vary depending on the density of the product Each bag of product such as CSB and wheat flour contain 25 kg of product A lot made up of two railcars would then contain 125 MT A plant packing off 16 bags per minute or 24 MT/hour would take about five hours to make a lot of two railcars In order to get 36 samples the inspector would need to sample about every 8 5 minutes of production Each sample would represent 140 bags or 3 5 MT In rare instances where the production plant is located near a shipping port trucks are used instead of railcars In that case the producer may chose to make lot sizes smaller than railcar quantities

Shipping and Storage

Most of the commodities are produced at the plant and loaded immediately after packaging into a railcar In rare instances the commodity may be sent by truck or stored at the plant a week or two prior to shipping The railcars have cardboard sheets on the floor Some plants use cardboard slip sheets so that the bags can be loaded with lift trucks, but most are loaded and unloaded by hand The railcar is inspected before and after loading by the FGIS inspector, who then seals the door to the car

The commodity is then shipped by rail to a terminal port, usually in Texas or Louisiana It is loaded into U S registered ships, which typically make a standard circuit from port to port This can take from one to six weeks Some PVOs reported that the commodity can get wet while in the ship At the port the

[15] These letters are a commodity code and not an abbreviation

commodity is unloaded into trucks and brought to a PVO run warehouse where it is stacked These central warehouses are inspected by local USAID missions The ones visited in this project were all clean well maintained with non-excessive temperature and humidity conditions

From this central warehouse the commodity is distributed throughout the country by truck In the case of Tanzania, this involved a long trip to the refugee camps, but that is not the norm Bags stay in the central warehouse from a week up to four or five months as they are drawn from stock They usually go to a smaller regional warehouse and from there to the feeding or distribution site Once the bags get to the actual distribution site, they are used up fairly quickly, usually within a week P L 480 commodities may be used anywhere from one to nine months after production, depending on the location of the recipient site and the situation there Rarely will commodities not be used within a year after production