
APPENDIX A.

Literature Review

PAST STUDIES ON UNIFORMITY AND STABILITY OF ADDED MICRONUTRIENTS

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.

b-carotene, like vitamin A, is susceptible to oxidation which results in reduced vitamin A activity. The stability of **b**-carotene in cereal flours has not been reported. **b**-carotene retention during baking was 80% in bagels and cake and 70% in cookies (15). Others report **b**-carotene retention during baking ranged from 85-96% in bread and 77-82% in crackers while no loss in **b**-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
	cornmeal	12 wk / 45°C	71
		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	
		6 mo / 21-32°C	80
		6 mo / 40°C	50
85	corn flour	6 mo / 4°C	85
		6 mo / 21-32°C	80
		6 mo / 40°C	50
	flour	6 mo / RT	100
		breadbaking	83
Rubin et al. (1977)	cornmeal	6 mo / RT	98
	corn grits	cooking (5 min)	87
		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.

Ascorbic Acid	Storage Temp. (°C)	Destruction rate k x 1000 CSM moisture content (%)		
		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-polyphosphate 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 USAID¹. 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 Commodities². 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 and/or between bags. The large variability observed in the iron data indicates that blending of the mineral mix into the commodities was also inadequate. Identification of inadequate mixing of the premixes into the blended foods at the mill level has initiated new quality control procedures by ASCS as discussed below.

The Technical Review Group, convened in July 1990, recommended that the level of iron from ferrous fumarate be increased from 15 to 30mg per 100g in the blended food commodities, and that the level of added iron from reduced

¹ USAID Program No. BP 612786.H9900

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

iron be increased from 2.9 to 4.4mg/100g to 8.8mg/100g in all protein fortified and other processed foods. A study commissioned by USAID Bureau for Humanitarian Response was undertaken to determine if these increases in iron fortification would affect the sensory properties of CSB, WSB, and SFCM. The study found no significant differences in overall flavor quality between the currently used (15mg iron/100g) and the increased levels (30mg iron/100g) of added iron for all the commodities with the exception that the wheat flavor of WSB after nine months of storage was different in the sample containing the highest level of ferrous fumarate. No explanation was given for this difference, and it was concluded from the overall flavor quality ratings that there would be no detrimental effect if iron levels were increased.

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

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

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/100g as compared with an expected level of approximately 600mcg. The marked variability of the vitamin A content of CSB within bags confounded the interpretation of results on the stability of vitamin A since much of the differences noted could have been the result of inadequate addition and/or blending of the vitamin premix. Group averages, however, indicated that losses of approximately 30 to 45 percent may have occurred during the 4 to 6 month period.

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 recommended 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/100g 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 100g of processed cereal in place of hydrogen reduced iron. This will provide more absorbable iron than would be provided by doubling the amount of hydrogen reduced iron.

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/100g 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 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.

NAS Vitamin C Fortification of Food Aid Commodities Report

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/100g.

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 be 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 15 mg/100g to 30 mg/100g. 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 13 mg to 20 mg/lb (2.9 mg to 4.4 mg/100g) to 40 mg/lb (8.8mg/100g). 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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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 at \$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 through 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 from 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.

² Abstracts of directly relevant 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 AACCC 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 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

Cooking Time (min)	Type/% WSB in <u>Gruel</u> product:		<u>Paste</u>		
	Vitamin C level added:	Normal	High	Normal	High
	pH:		6.9	6.8	6.8
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

Cooking Time (min)	<u>Beverage</u>		<u>Gruel</u>		<u>Paste</u>		
	Vitamin C level:	Normal	High	Normal	High	Normal	High
	pH:	6.8	7.2	6.6	6.7	6.9	6.8
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

<u>Beverage</u>	<u>Gruel</u>	<u>Paste</u>	<u>Dumpling</u>
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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 evaporation				
	8.3%	13.8%	20.0%	41.5%

Appendix D.1

Laboratory Food Preparation Studies - Vitamin A Results

WHEAT SOY BLEND

	Type of <u>Gruel</u>		<u>Paste</u>		<u>Dumpling</u>		
	Food: 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
	Assayed level of vitamin A (IU/100g) in food product						
Cooking Time (min.)							
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

	<u>Beverage</u>		<u>Gruel</u>		<u>Paste</u>	
	Normal	High	Normal	High	Normal	High
	Starting level of vitamin A (IU/100g) in food based on calculation					
	170	179	282	298	407	429
	Assayed level of vitamin A (IU/100g) in food product					
Cooking Time (min)						
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:	<u>Gruel</u>		<u>Paste</u>		<u>Dumpling</u>	
	Normal	High	Normal	High	Normal	High
Vitamin C level added:						

Starting level of vitamin C (mg/100g) in food based on calculation

5	13	7	18	15	38
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Cooking Time (min.)

Assayed level of vitamin C (mg/100g) in food product

0	3	9		12	23
5			5	13	17
10	3	9			
15		9	5	11	13
20	3	8			
30	3	9			13
45			5	12	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

<u>Beverage</u>	<u>Gruel</u>		<u>Paste</u>	
	Normal	High	Normal	High

Starting level of vitamin C (mg/100g) in food based on calculation

2	8	3	13	7	19
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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			Wetted & Heated
				3 min	6 min	10 min	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: d- top of the bag e- middle of the bag f- 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.2Data 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

Appendix D.2**Data on Samples Collected in Bolivia**

Contract	Lot	Bag	Vitamin A (IU/100g)	
		Location	FGIS	Bolivia
1635	1704	A	1090	1,430
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)		Difference
				at Production	in Haiti	
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

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)		Difference	
				at Production	in Haiti		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	
<hr/>							
	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.	

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 5.3
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				Vitamin A	Vitamin C	Niacin	Moisture	Water
LOT No.	Sampled	Location	Lot	IU./10g	mg/100g	mg/100g	%	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
A0153AC	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	Bag	Vitamin A (IU/100g) in Peru
						Number	Location	
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

Bag location- position of the bag the sample was taken from:

Location- city or town where warehouse is located

a- top of the bag

Contract- number printed on bag

b- middle of the bag

Lot- number stamped on bag

c- bottom of the bag

Date- sample taken on this day

Bag number- arbitrary number for scientific purposes

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 wet basis (mg/100g)	Milligrams of Vitamin C per 100 grams of cooked food preparation after cooking , based on total weight (including moisture)
Vitamin C in food mixture dry basis (mg/100g)	Milligrams of vitamin C per 100 grams of cooked food preparation after cooking , 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: g- top of the bag h- middle of the bag

i- 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 in food mixture after cooking, wet basis (mg/100g)
1	gruel	7.67	79.6	20.5	8.8	9.5	1.3	
2	gruel	7.82	73.9	26.3	10.0	10.8	1.7	
3	gruel	7.73	79.5	22.0	8.4	9.1	1.5	
4	gruel	7.61	77.7	20.8	8.8	9.5	1.9	
5	gruel	7.70	76.4	19.9	8.9	9.6	1.6	
Average		7.71	77.4			9.7		
Standard Deviation		0.08	2.4			0.7		
6	dumplings	7.79	59.1	25.6	8.4	9.1	3.0	
7	dumplings	7.64	56.3	22.8	8.7	9.4	3.9	
8	dumplings	7.62	61.8	20.6	8.5	9.2	2.8	
9	dumplings	7.52	64.4	20.7	8.9	9.6	3.3	
10	dumplings	7.78	57.7	20.5	8.7	9.4	2.4	
Average		7.67	59.9			9.4		
Standard Deviation		0.11	3.3			0.2		
11	gruel	7.55	81.0	22.6	9.2	10.0	1.6	
12	gruel	7.71	83.0	20.4	9.6	10.4	1.3	
13	gruel	7.60	79.9	21.2	9.4	10.2	1.5	
Average		7.62	81.3	21		10.2		
Standard Deviation		0.08	1.6	1		0.2		
16	dumplings	7.60	61.0	22.6	9.4	10.2	3.4	

Appendix D.3

Analytical Data on Cooked Samples of CSB from Tanzania

21 CSB Samples

Sample No	CSB (g)	Times (min)		Final Wt. (g)	Other Ingredient (g)	Product Type	CSB %	Water (%)	Assayed Level			Calculated Level		
		total	cook						Vit A (IU/100g)	Vit C (mg/100g)	Niacin (mg/100g)	Vit A (IU/100g)	Vit C (mg/100g)	Niacin (mg/100g)
1	620	2100	7	7		Ugali	22.8	51.4	1210	18	4.3	517	21	1.9
2	370	4400	18	11		Gruel	7.8	92.6	60	4	0.9	168	7	0.7
3	450	2870	9	6		Gruel	13.6	88.4	130	5	1.3	289	12	1.2
4	270	1760	11	8		Gruel	13.3	88.5	90	6	1.3	281	13	1.2
5	530	770	6	4	890	Ugali	40.8	61.0	740	15	3.6	824	39	3.5
6	241	2475		9.5		Gruel	8.9	86.5			0.8	79	3	0.5
7	222	1741		8.5		Gruel	11.3	85.0	60		1	105	3	0.6
8	195	1574		8		Gruel	11.0	89.7			1	72	2	0.6
9	843	4690		10.5		Gruel	15.2	89.9	60	1	1	157	4	0.8
10	571	5449		8.5		Gruel	9.5	92.0	50		0.8	79	3	0.5
11	760	700	5	5	1160	Ugali	52.1	48.1	460	7	3.1	505	12	2.9
12	940	4500	23	20		Gruel	17.3	86.6	80	2	0.9	190	5	1.0
13	450	2300	19	15		Gruel	16.4	81.4	50	2	0.9	144	5	0.9
14	240	1730	11	6		Gruel	12.2	90.7	40	1	0.8	115	3	0.7
15	390	1740	24	12		Soup	14.1	80.9	110		0.9	160	4	0.8
16	724	1095		4	1442	Ugali	39.8	56.0	1800	57	6.3	1,540	64	5.6
17	506	3759	17	15		Gruel	11.9	89.1	200	14	1.6	419	19	1.7
18	250	1653	16.5	16		Gruel	13.1	87.7	390	16	1.7	489	21	1.8
19	791	1049		3.5	1577	Ugali	43.0	57.4	1510	49	5.8	1,603	60	6.0
20	401	3199		29		Gruel	11.1	86.4	260	13	1.5	485	18	1.6
21	410	370	5	5	572	Cake	71.7	39.8	410		3	760	20	3.9
				17 dumplings	7.98	62.9	21.2	9.4	10.2	3.3				
				18 dumplings	7.43	59.9	20.5	9.9	10.7	3.2				
				19 dumplings	7.68	47.5	20.7	9.5	10.3	3.1				
Average				7.67	57.8	21			10.3					
Standard Deviation				0.23	7.0	1			0.2					

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

Appendix

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

DRY CSB SAMPLES Sample	Vitamin A	Vitamin C	Niacin	Iron	Moisture	Water Activity
No.	(IU/100g)	(mg/100g)	(mg/100g)	(mg/100g)	(%)	(%)
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

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: j- top of the bag k- middle of the bag l- bottom of the bag

Appendix D.4Within Bag Samples of WSB Collected in Haiti

Sample Number	WATER (%)	VITAMIN A (IU/100g)	ASSAY		VITAMIN C level added
			VITAMIN C (mg/100g)	NIACIN (mg/100g)	
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

Appendix D.4Within Bag Samples of WSB Collected in Haiti

Sample Number	WATER (%)	VITAMIN A (IU/100g)	ASSAY		VITAMIN C level added
			VITAMIN C (mg/100g)	NIACIN (mg/100g)	
CSBVEPE00393b940	9.84	1260	21		
CSBVEPE00393c940	9.87	610	20		
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

Appendix D.4Within 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
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	Sample	Moistur	Vitamin	Vitamin	Iron	Niacin
			d	e	A	C		
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.4Corn Soy Blend samples in Tanzania taken from different parts of bags

Sample Number	Bag	Moisture %	Vitamin A IU/100g	Vitamin C mg/100g	Niacin mg/100g	Iron mg/100g	Water
	Location Sampled						Activity %
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)		Vitamin A (IU/100g)	
	at production	after frozen	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)		Vitamin A (IU/100g)	
	at production	after frozen	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

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/10 0g) Check
	No.	Time	Day	Lot	Assay	
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
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Analytical Data on WSB Made with Conventional Level of Vitamin C
from Plant B

SAMPLE No.	Time	Day	Lot	Vitamin C (mg/100g)			Niacin (mg/100g)			Vitamin A (IU/100g)		
				Assay	Rerun	in Haiti	Assay	Check	Assay	Check	Rerun	in Haiti
				Check								
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	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
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
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Analytical Data on WSB Made with High Level of Vitamin
C from Plant B

SAMPLE No.	Time	Day	Lot	Vitamin C (mg/100g)			Niacin (mg/100g)		Vitamin A (IU/100g)					
				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. Number	10.7	8.7	3.7	11.0	0.6	0.5	229	316	14	123
	48	11	6	31	48	11	49	11	3	10

Appendix

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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	Assay	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.	6.3	6.1	227	185	0.4	0.4	4.6	3.5
					Dev.								
					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 No.	Day	Time	Shift	Lot	Vitamin C (mg/100g)		Vitamin A (IU/100g)		Iron (mg/100g)		Niacin (mg/100g)	
					Assay	Check	Assay	Check	Assay	Check	Assay	Check
2-2000	2-Apr	200 ^e 0	2	28	55	68	3040	3300	24.4	25.2	7.1	7.2
2-2100	2-Apr	210 0	2	28	37		2610		22.8		6.7	
2-2200	2-Apr	220 0	2	28	47		3560		24.3		7.6	
2-2300	2-Apr	230 0	2	28	55		2840		21.2		6.7	
3-0100	3-Apr	100	3	28	49	54	3400	3200	23.6	23.2	7.9	7.9
3-0300	3-Apr	300	3	28	40		2600		19.3		6.6	
3-0400	3-Apr	400	3	29	42		2490		19.1		6.3	
3-0500	3-Apr	500	3	29	46		2870		22.3		6.4	
3-0600	3-Apr	600	3	29	41		3280		24.8		7.5	
3-0700	3-Apr	700	3	29	42		3210		23.5		7.4	
3-0800	3-Apr	800	1	29	56	59	3730	3670	26.3	27.6	8.4	8.2
3-0900	3-Apr	900	1	29	47	38	2770	2860	21.2	21.2	7.1	6.9
3-1140	3-Apr	114 0	1	29	42		2420		20.0		6.4	
3-1330	3-Apr	133 0	1	29	56		2790		22.8		7.6	
3-1430	3-Apr	143 0	1	29	75		5190		38.0		11.0	
3-1800	3-Apr	180 0	2	29	39	48	3470	3110	24.2	24.0	7.8	7.4
3-1900	3-Apr	190 0	2	29	37		2760		20.4		6.9	
3-2100	3-Apr	210 0	2	29	32		2630		19.2		7.1	
4-0000	4-Apr	0	3	30	36	48	2810	2920	23.4	23.8	7.2	7
4-0100	4-Apr	100	3	30	40		2960		23.1		7.7	
4-0200	4-Apr	200	3	30	36		2360		21.1		7.2	
4-0300	4-Apr	300	3	30	45		3240		23.9		7.7	
5-0200	5-Apr	200	1	30	38		2400		21.2		5.6	
5-0300	5-Apr	300	1	30	43	51	3770	3980	26.7	26.0	7.9	8.1
5-0400	5-Apr	400	1	31	43		3350		24.6		7.8	
5-0500	5-Apr	500	1	31	32		2350		20.8		5.9	
5-0600	5-Apr	600	1	31	38		2790		20.4		7.3	
5-0700	5-Apr	700	1	31	46		3700		25.6		8.6	
5-0900	5-Apr	900	2	31	43		3040		24.0		7.5	
5-1000	5-Apr	100 0	2	31	34		2820		22.0		7.3	
5-1100	5-Apr	110 0	2	31	48		2980		25.2		7.6	
5-1200	5-Apr	120 0	2	31	57	55	2970	3050	22.7	23.1	7.8	7.8

5-1700	5-Apr 170 0	3	31	35		2470		18.8	6.7		
5-1800	5-Apr 180 0	3	31	48		2820		22.7	7.5		
5-1900	5-Apr 190 0	3	31	49		3070		23.1	8.4		
5-2000	5-Apr 200 0	3	31	51		2470		18.6	6.5		
5-2100	5-Apr 210 0	3	31	47		2910		22.5	7.4		
6-0000	6-Apr 0	1	32	46		2660		20.7	7.0		
6-0100	6-Apr 100	1	32	61		3170		23.8	8.2		
6-0200	6-Apr 200	1	32	38	34	2450	2320	18.8	18.2	6.5	6.5
6-0300	6-Apr 300	1	32	40		2400		19.3	6.5		
6-0400	6-Apr 400	1	32	45		3110		23.1	7.4		
6-0500	6-Apr 500	1	32	37		2510		20.1	6.8		
6-0700	6-Apr 700	1	32	53		2750		21.8	7.2		
6-1100	6-Apr 110 0	2	32	31	33	2540	2730	19.9	21.1	6.5	7.2
6-1400	6-Apr 140 0	2	32	39		2230		19.8	6.3		
6-1500	6-Apr 150 0	2	32	38		2900		22.5	7.4		
6-1600	6-Apr 160 0	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			<u>Vitamin A (IU/100g)</u>		<u>Iron (mg/100g)</u>	
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	2800		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	5.0	
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	2520	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 powdered 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.

Sample Designation	Vitamin A (IU/100g)		Added	% of minimum	% of added
	Assay	Bag mean			
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

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 (C_p) is the ratio of the Upper Control Limit (UCL) less the Lower Control Limit (LCL) to the maximum–minimum specification. Ideally, the C_p should be above 1.0, meaning that specified range could be achieved 99% of the time. For low C_p s, as in these cases, the C_{pk} is more meaningful. The C_{pk} 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 C_{pk} 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 $\pm 40\%$.

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

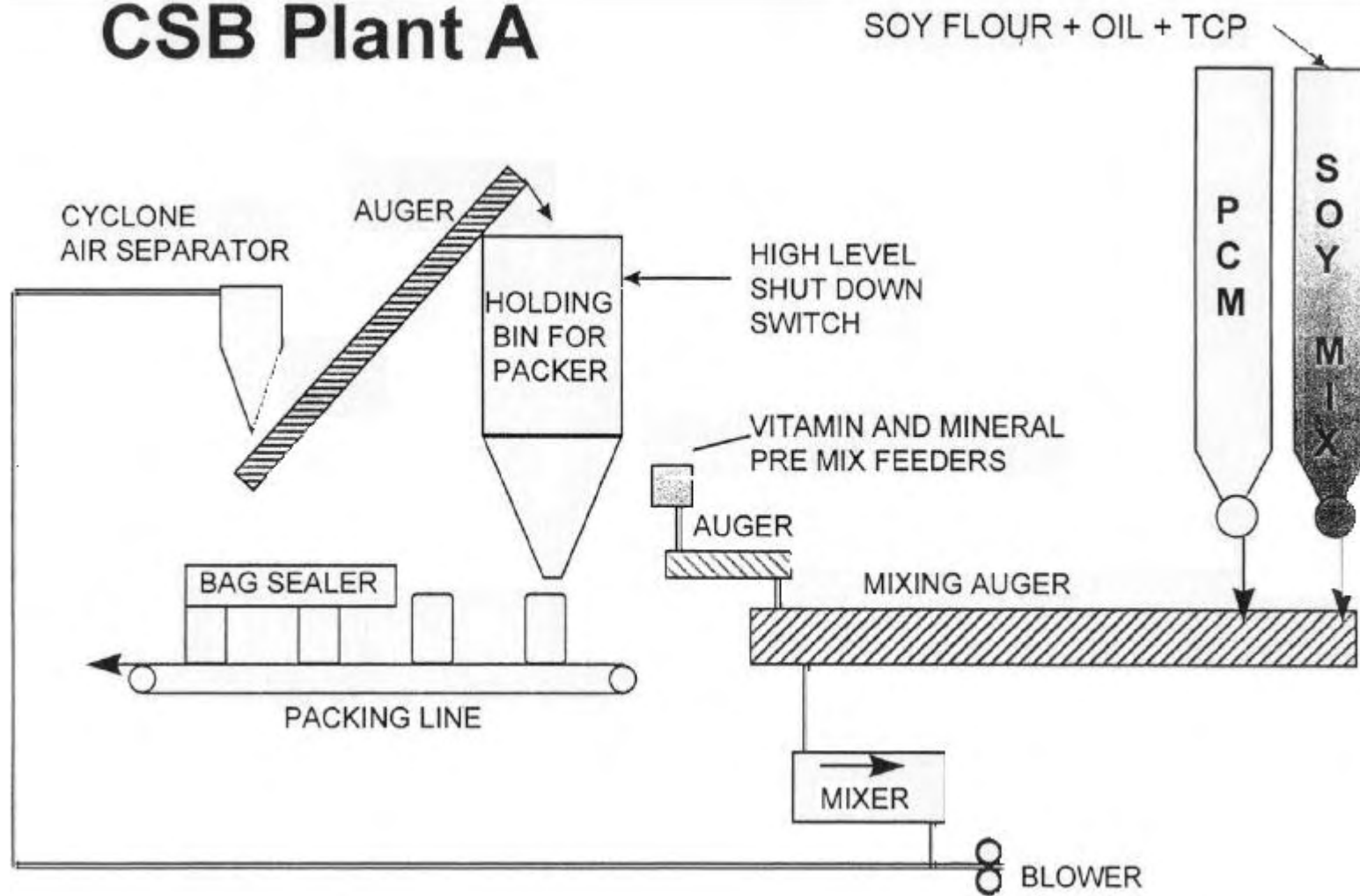
fortified bulgur was moved through a conveyor where defatted soy flour was added (in the case of soy fortified bulgur). This conveyor led directly into a ten-foot, cut-flight mixing conveyor.

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.

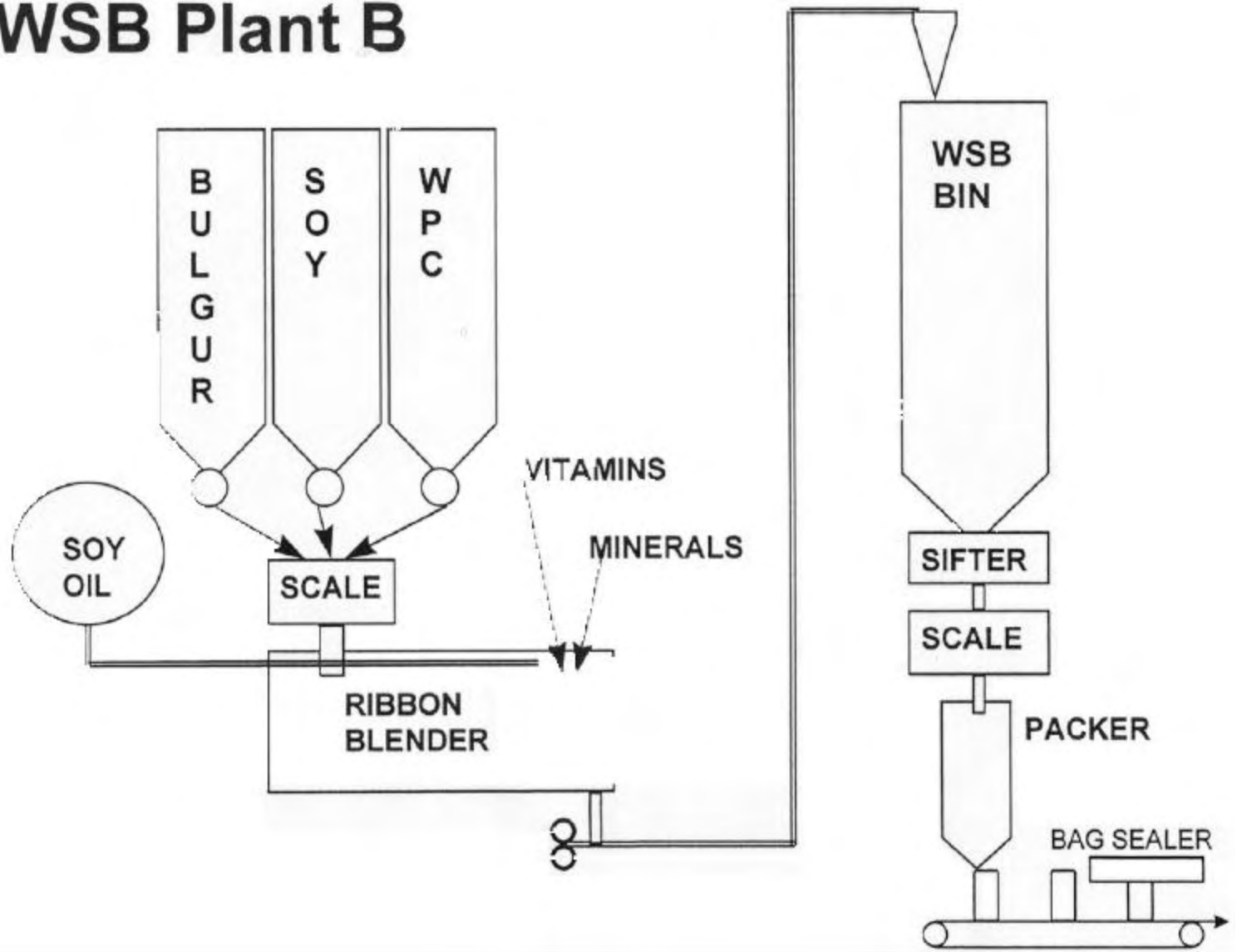
Plant H

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.

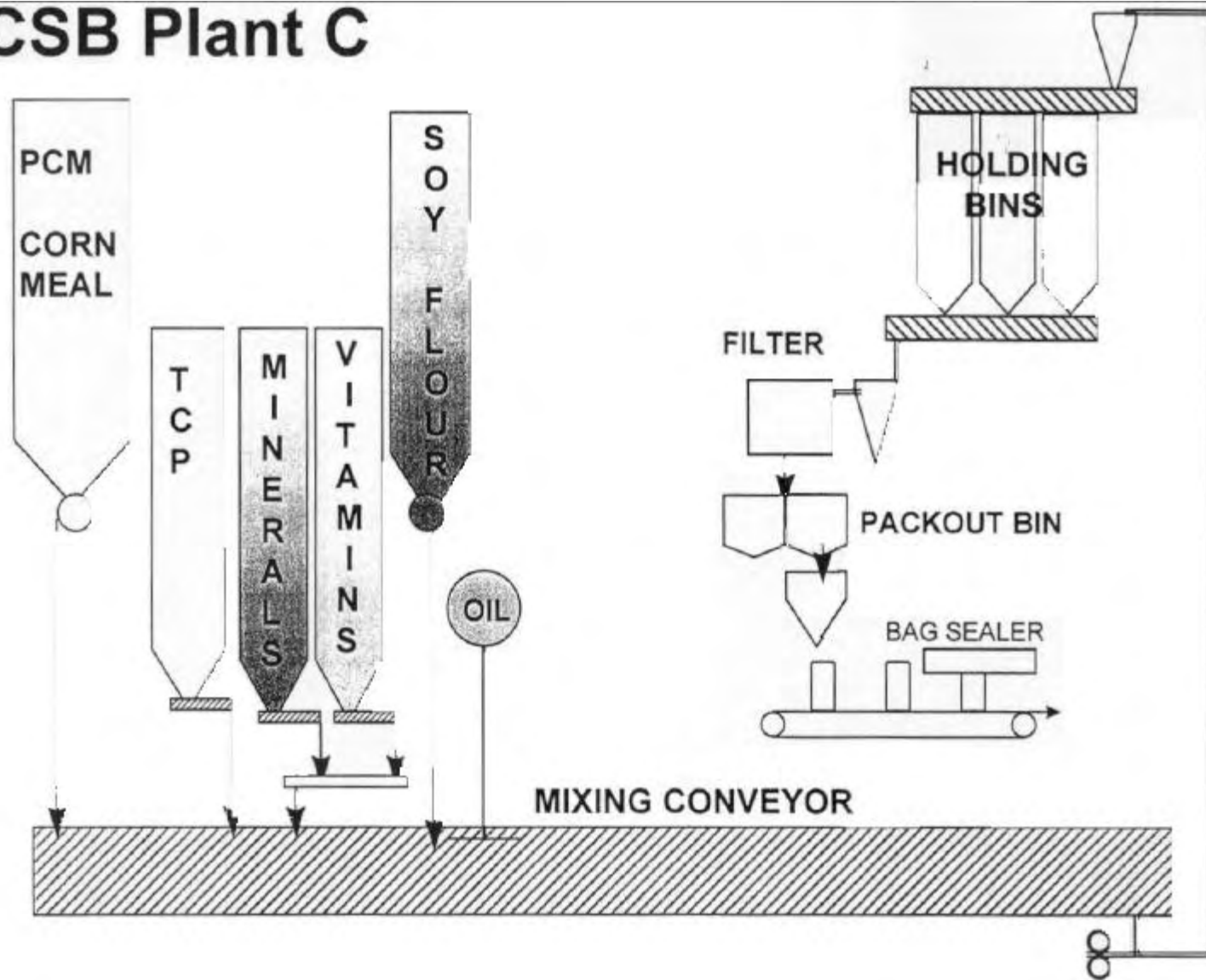
CSB Plant A



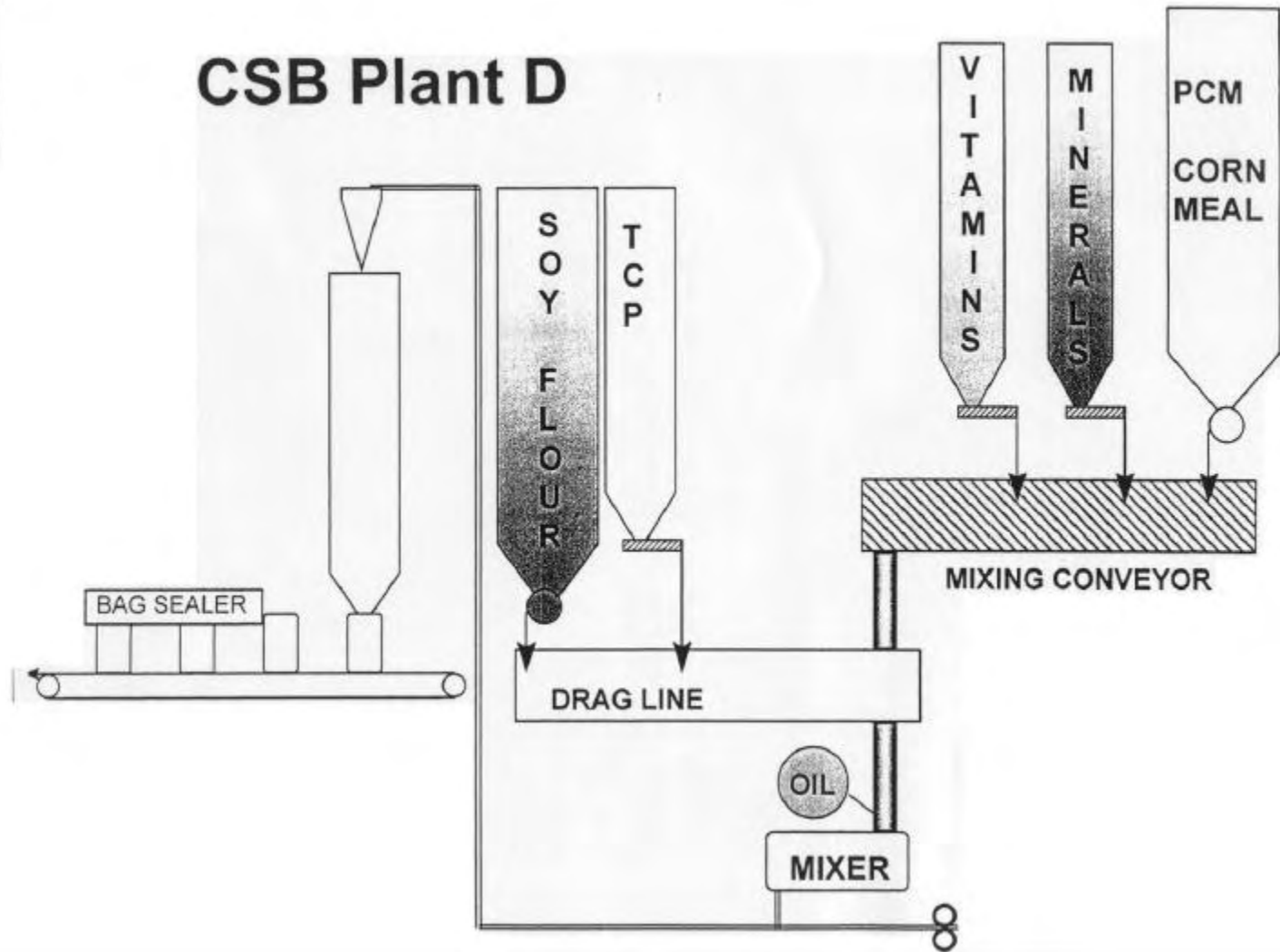
WSB Plant B



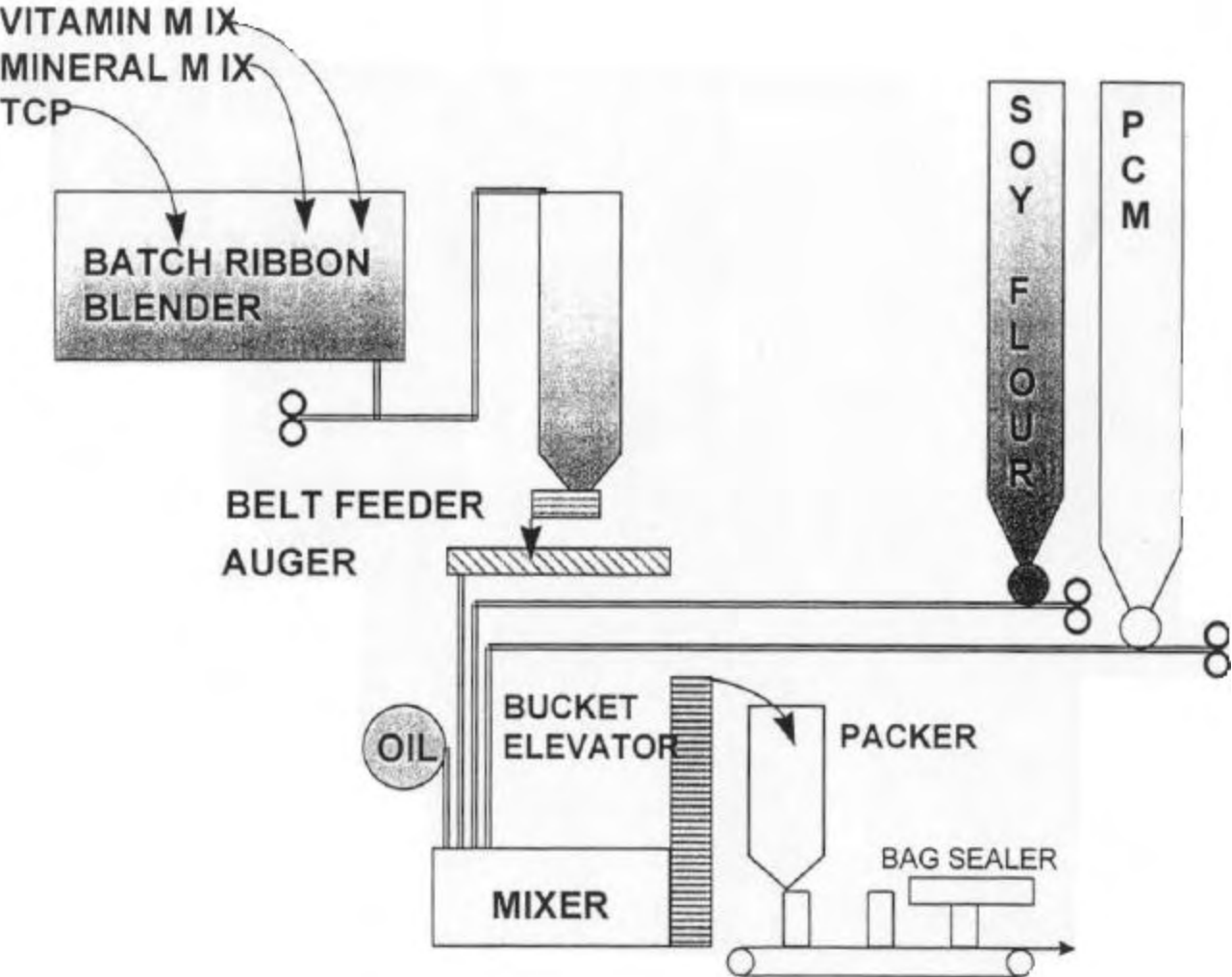
CSB Plant C



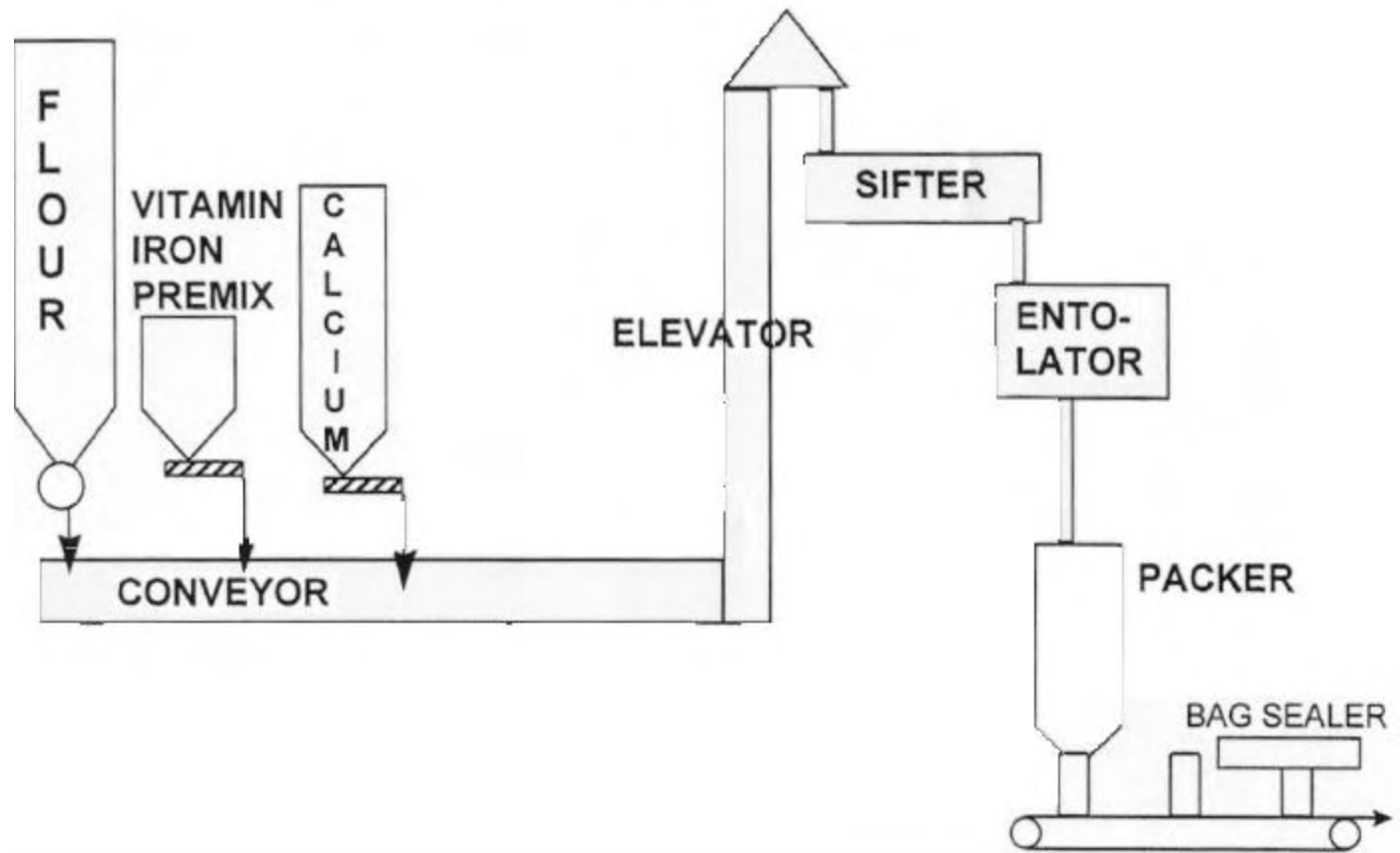
CSB Plant D



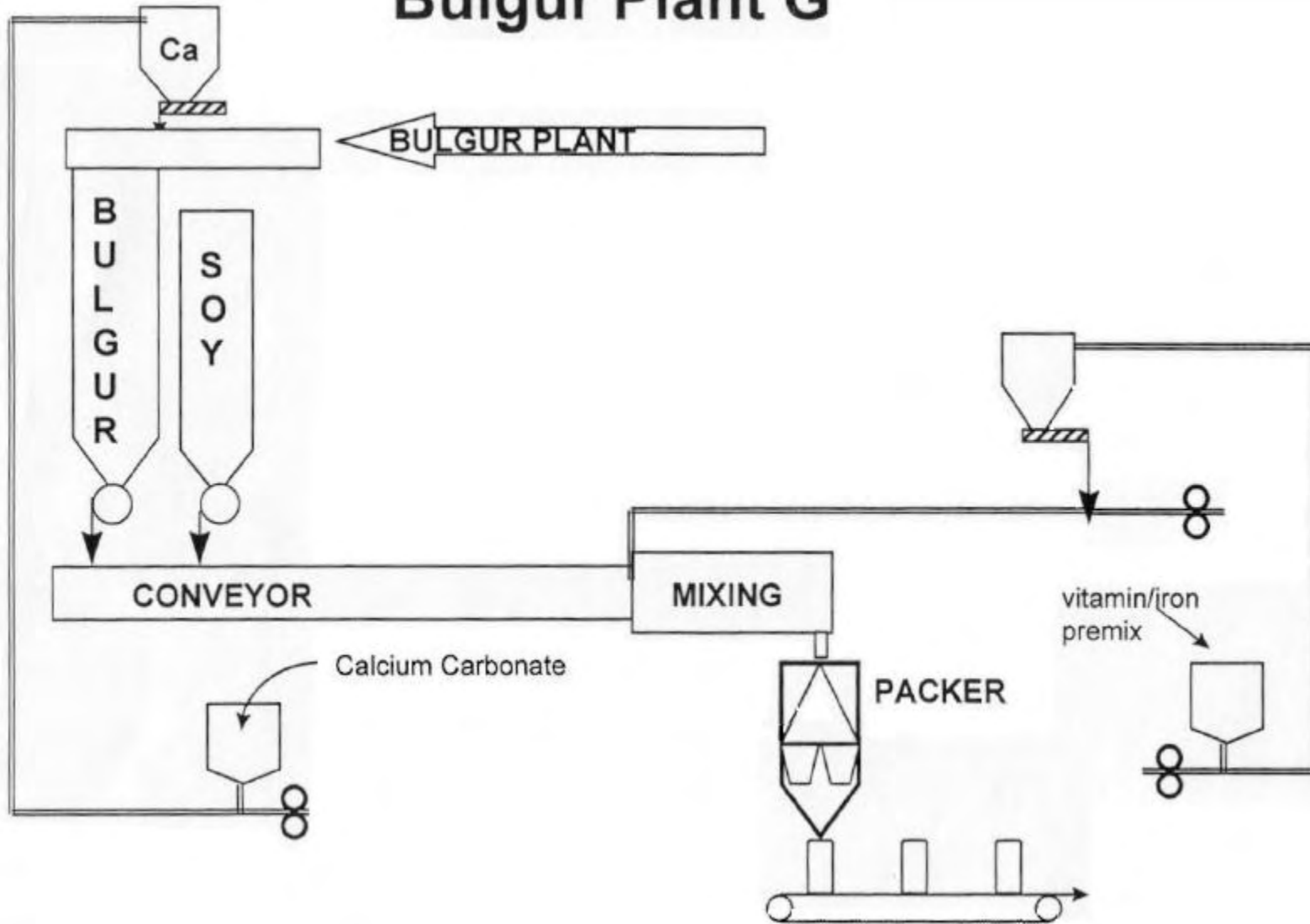
CSB Plant E



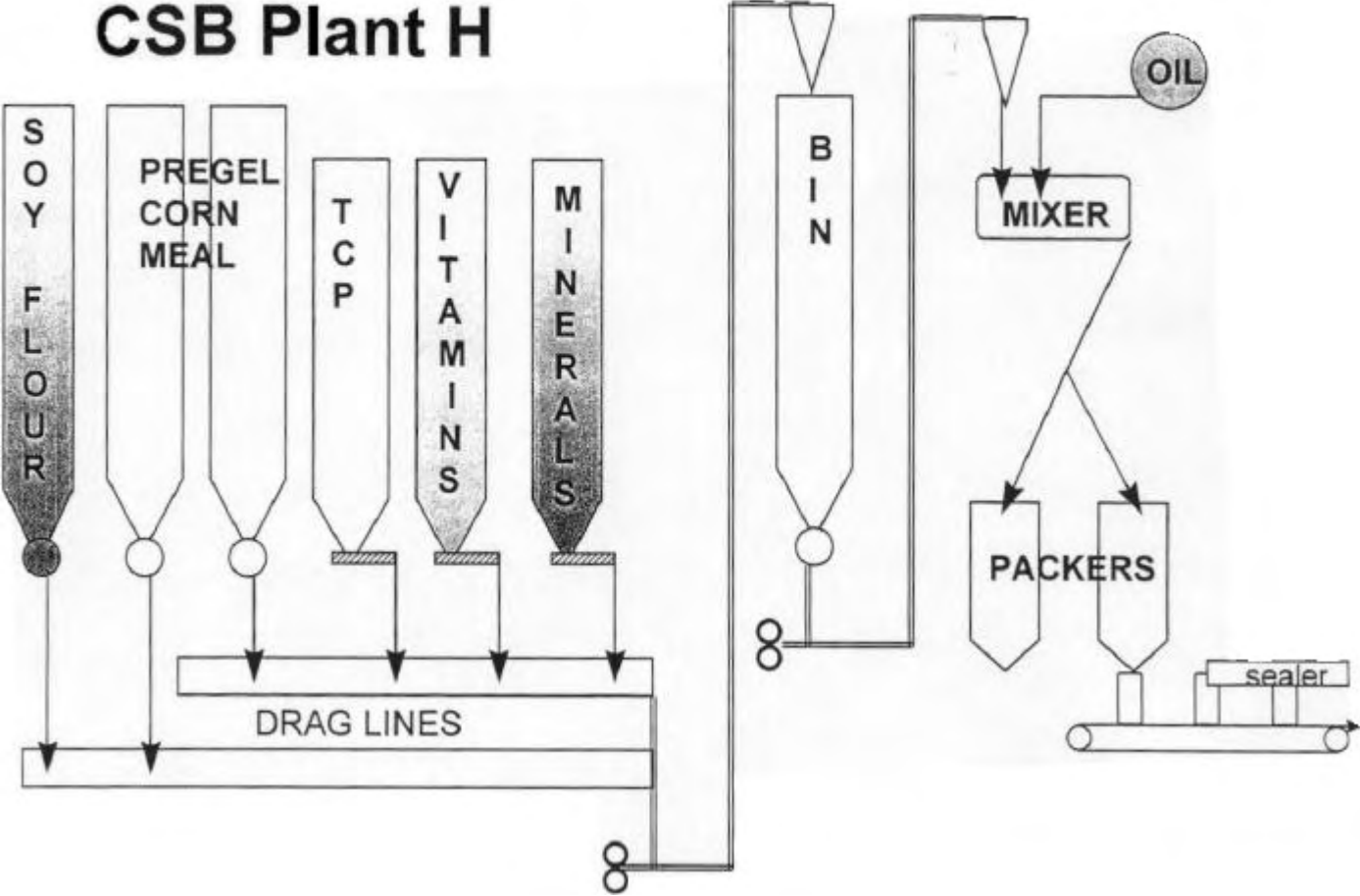
Wheat Flour Plant F



Bulgur Plant G



CSB Plant H



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.

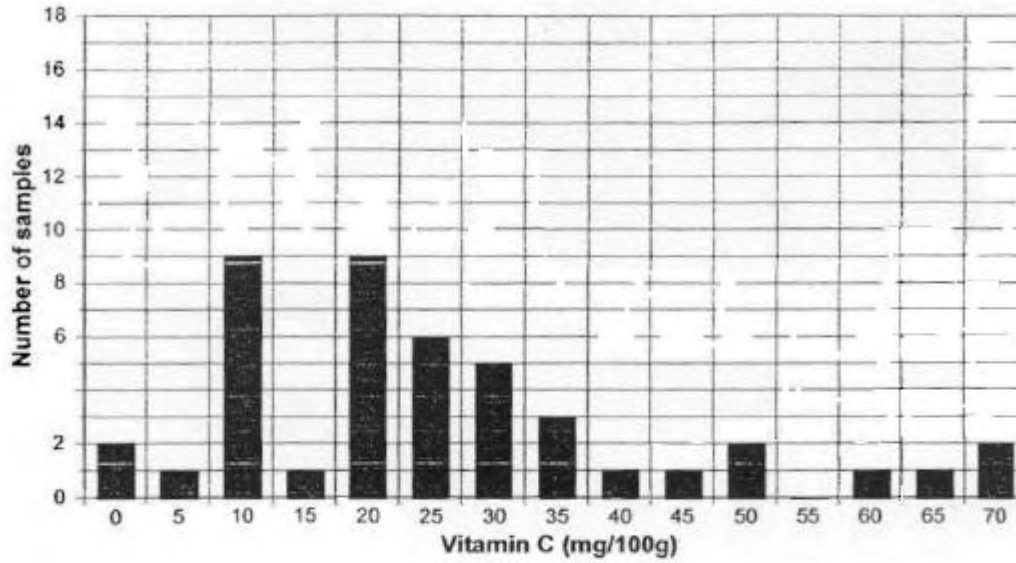
Also shown on the right side of each control chart is the NIST standard, representing the analytical error for each micronutrient assay. Each day a set of samples were tested for a particular micronutrient, a standard reference sample with a certified level of that micronutrient was tested as well. If 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

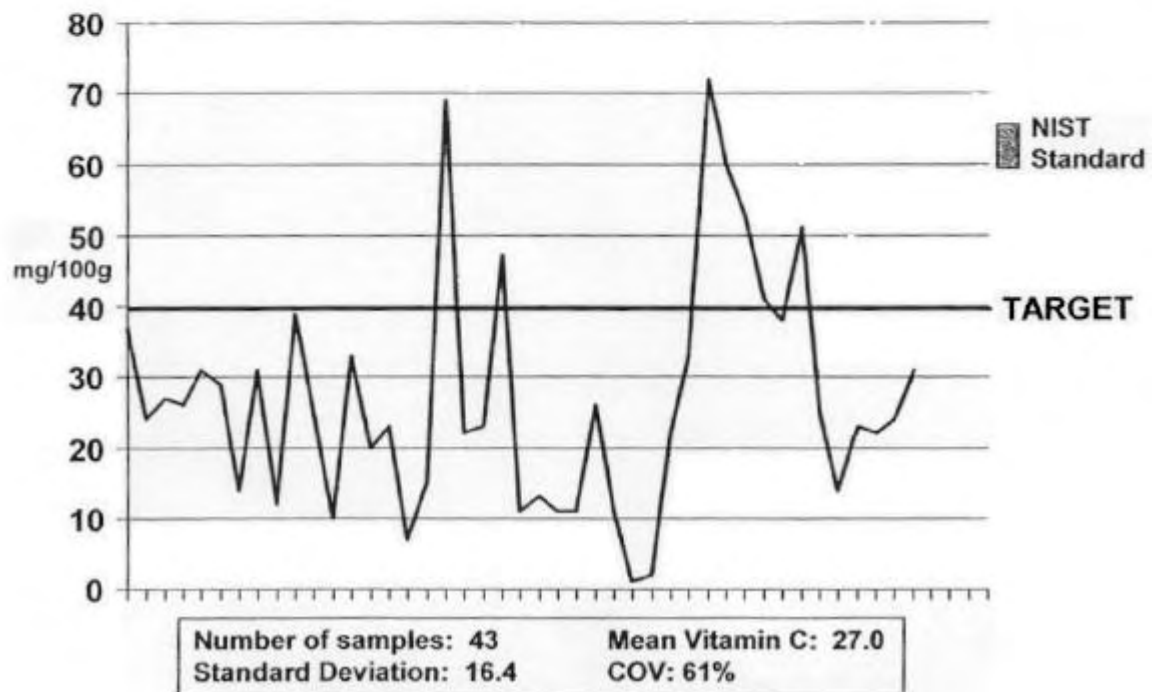
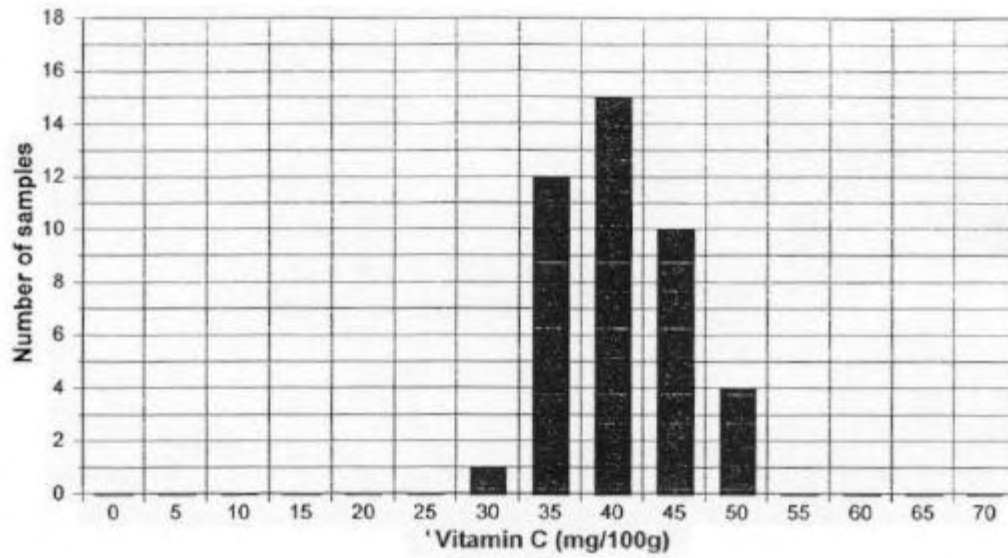


Fig. 2 - Vitamin C in WSB at Plant B

Histogram



Control Chart

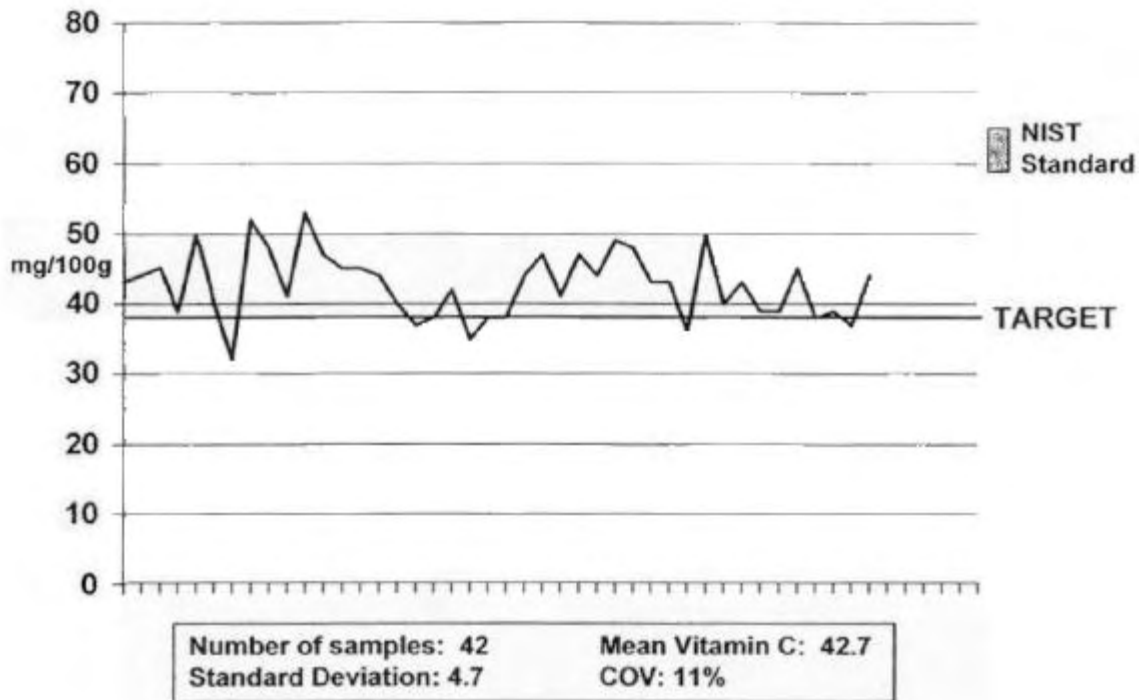
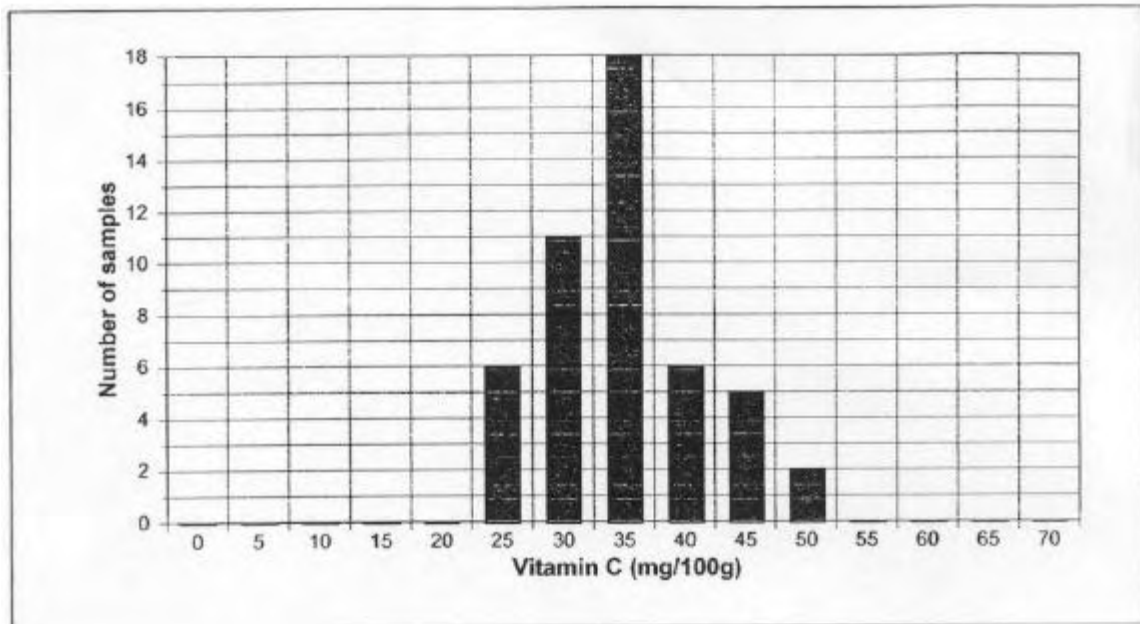


Fig. 3 - Vitamin C in CSB at Plant C

Histogram



Control Chart

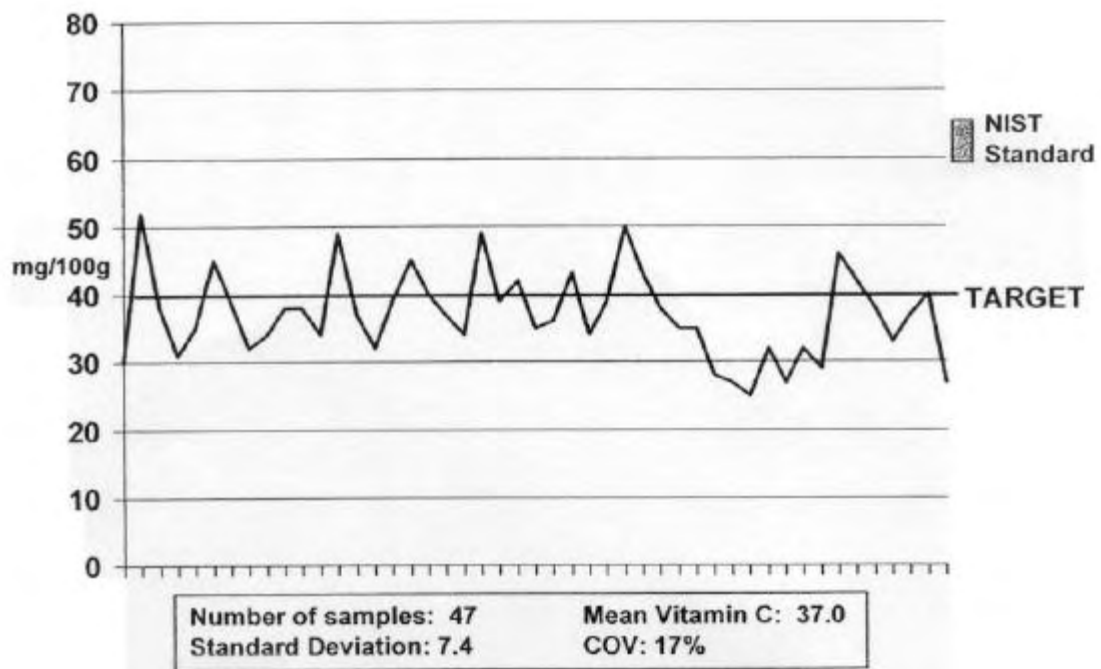
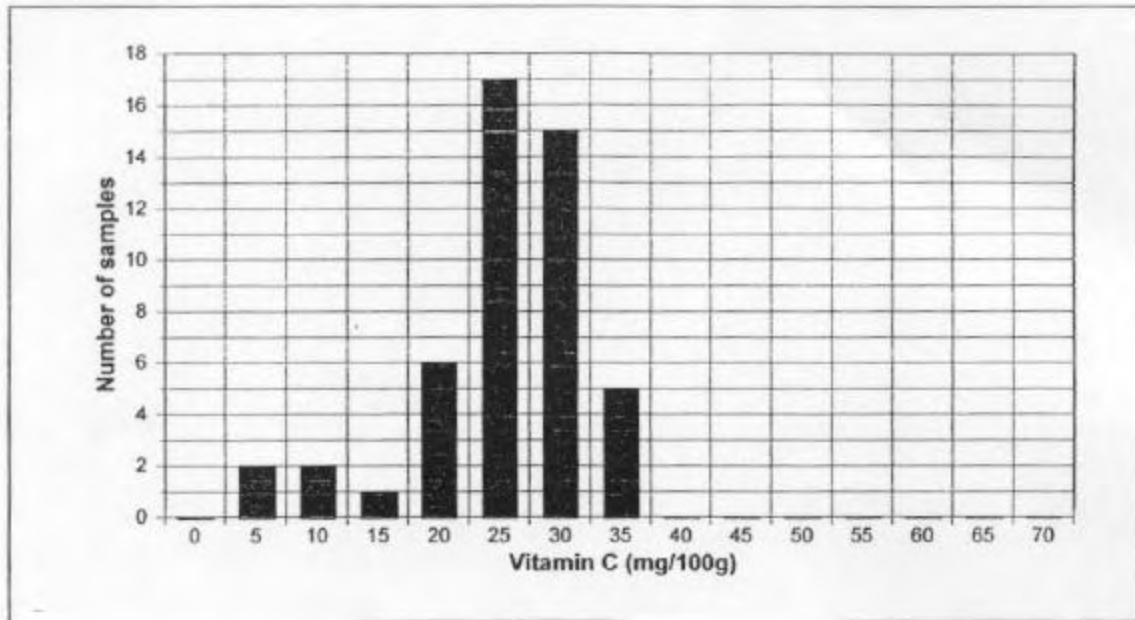
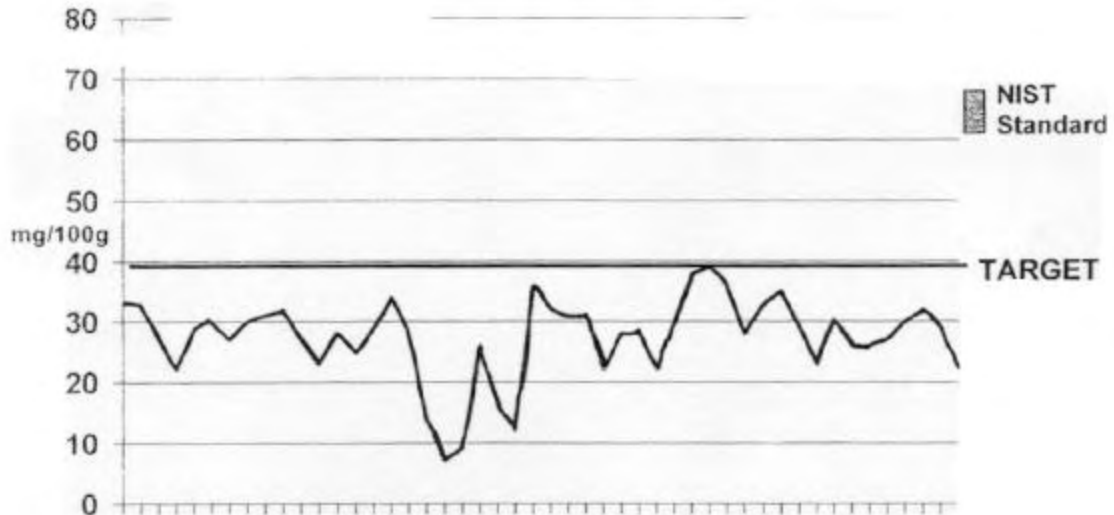


Fig. 4 - Vitamin C in CSB at Plant D

Histogram



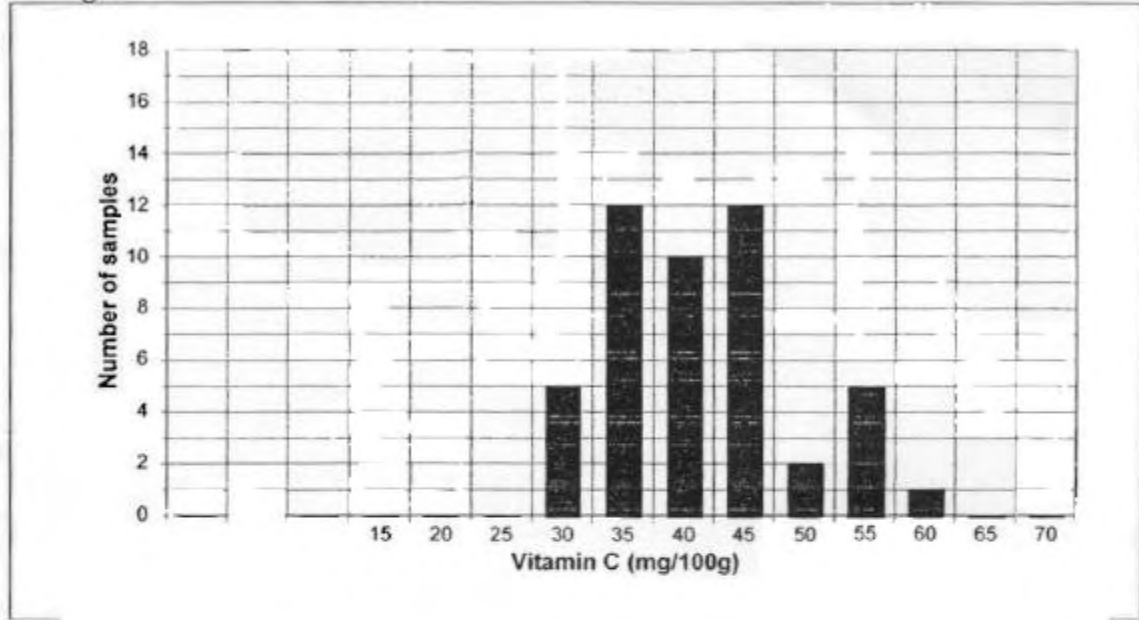
Control Chart



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

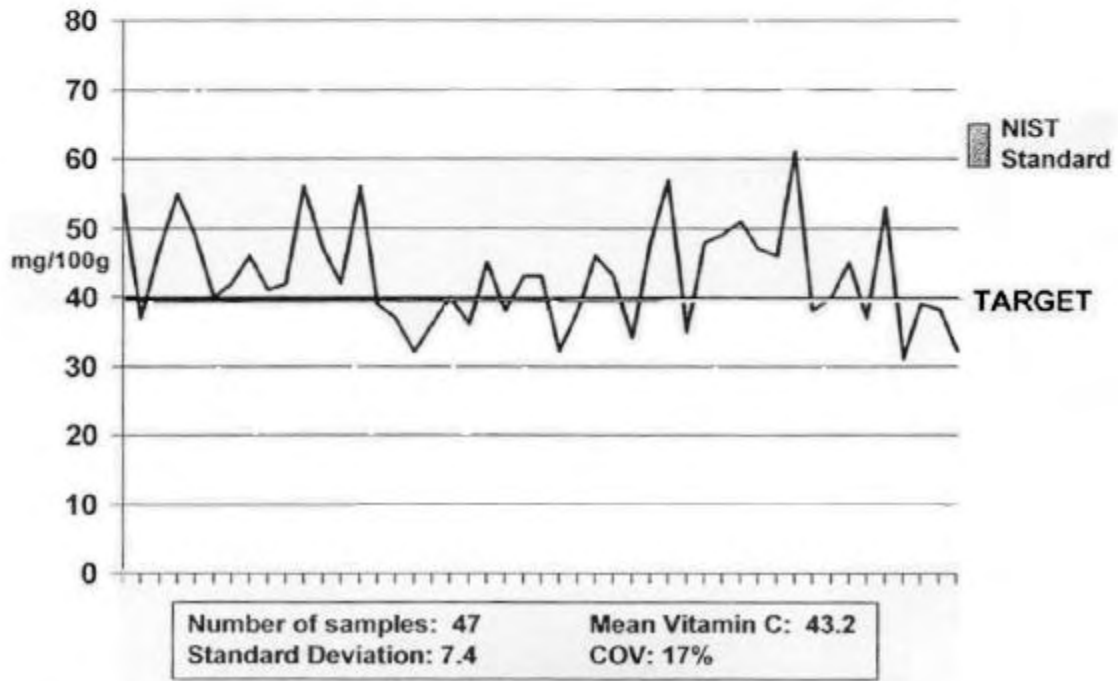
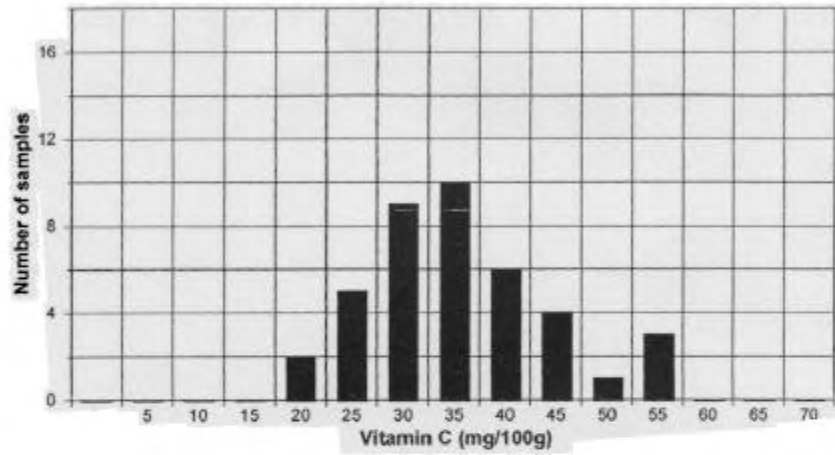


Fig. 6 - Vitamin C in CSB at Plant G

Histogram



Control Chart

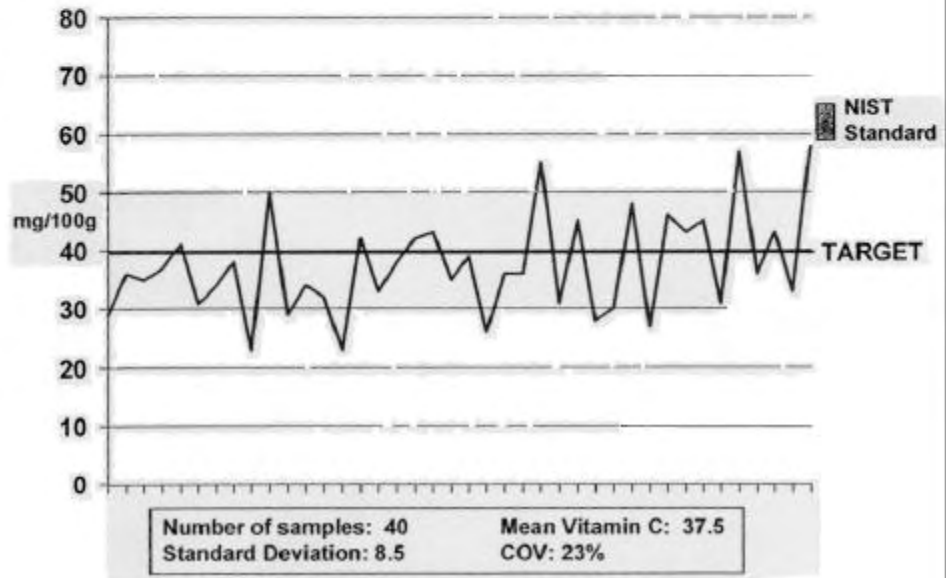
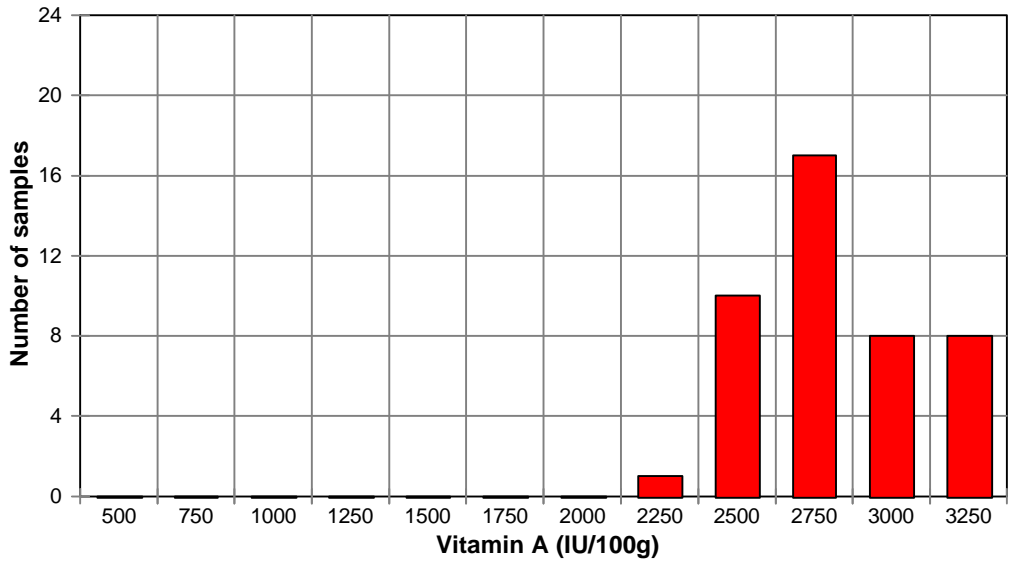


Fig. 7 - Vitamin A in WSB at Plant B

Histogram



Control Chart

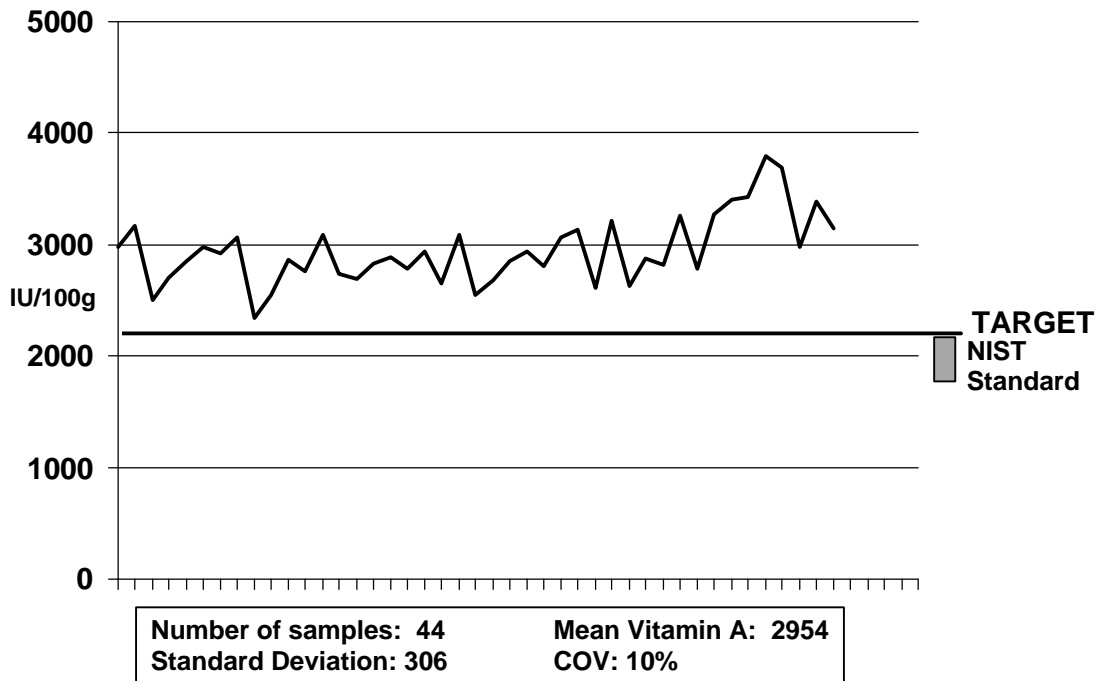
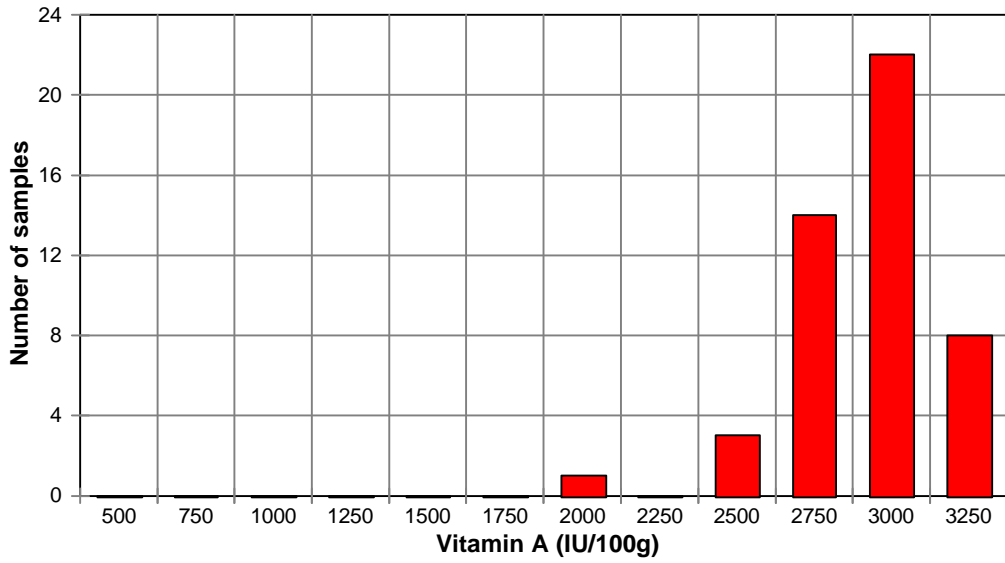


Fig. 8 - Vitamin A in Corn Meal at Plant C

Histogram



Control Chart

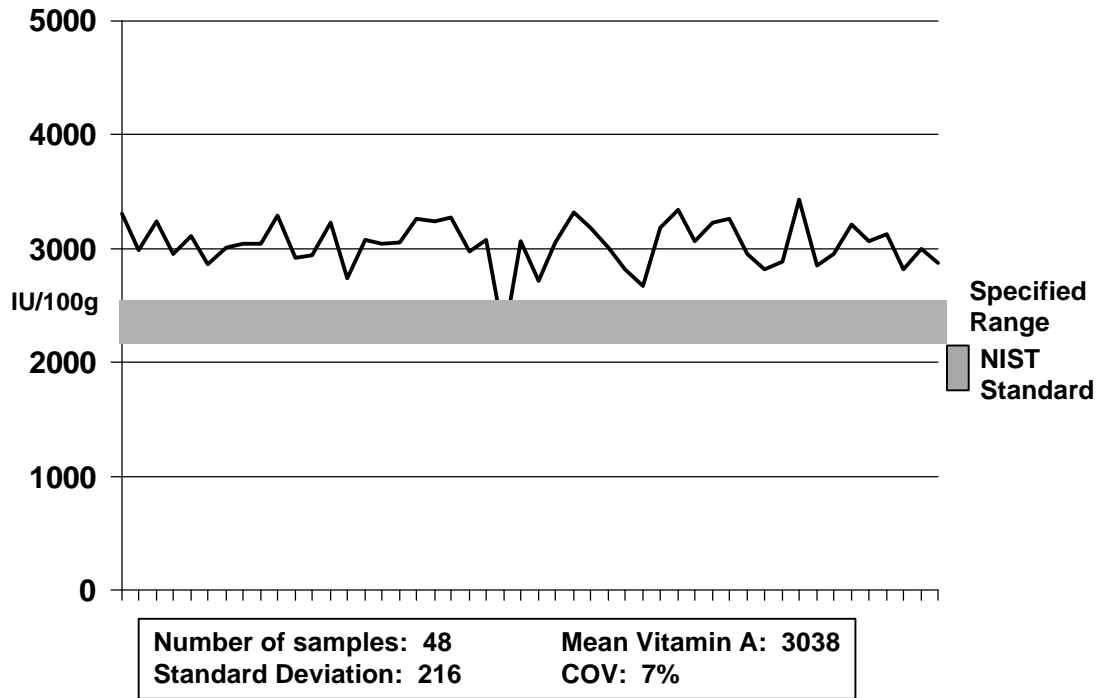
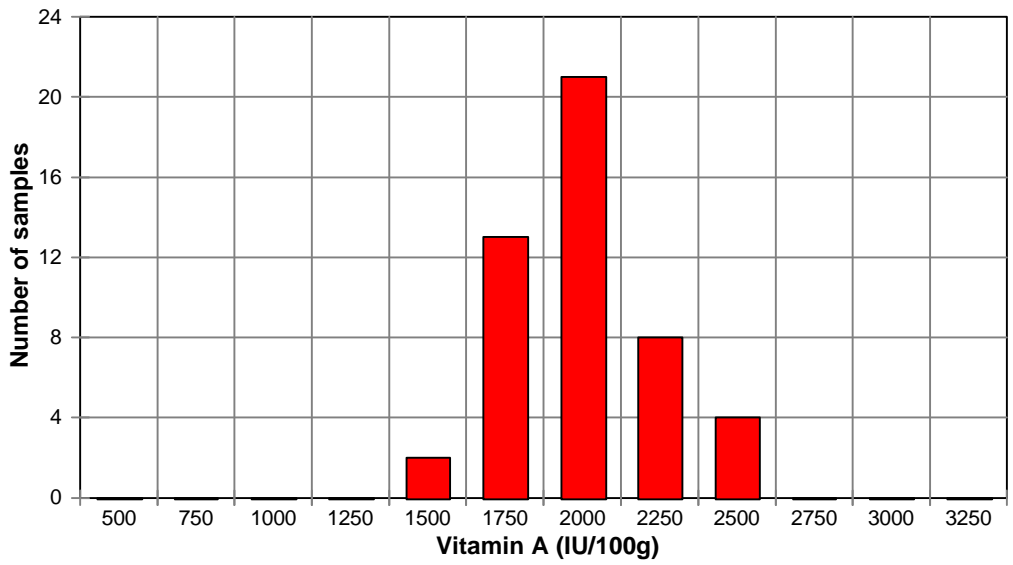


Fig. 9 - Vitamin A in CSB at Plant C

Histogram



Control Chart

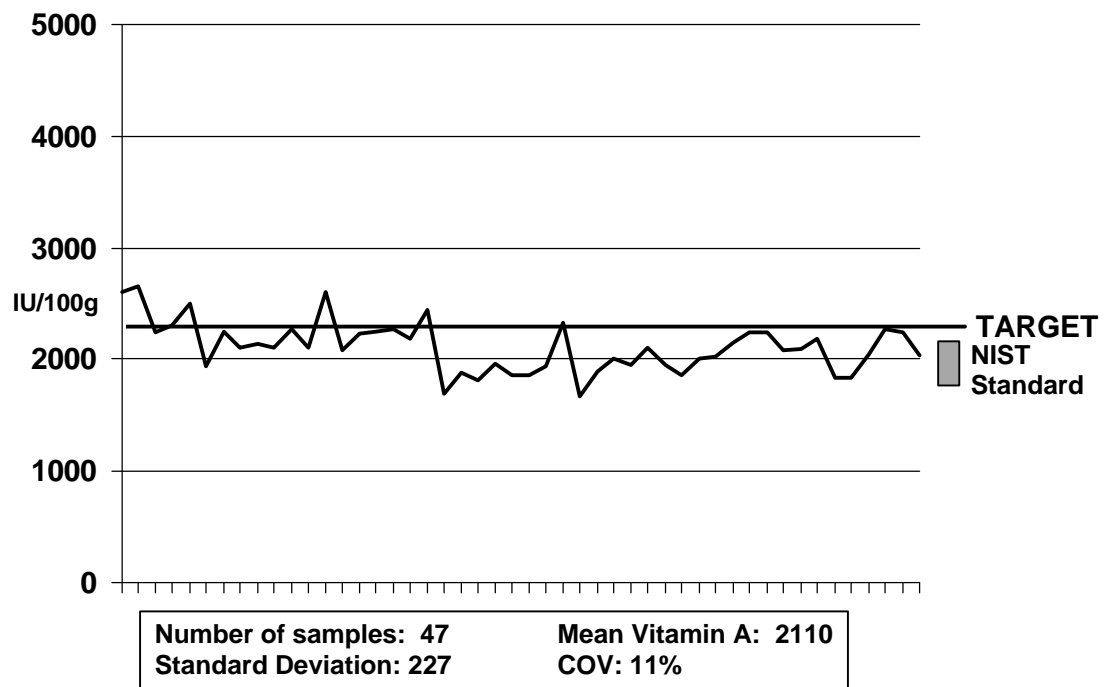
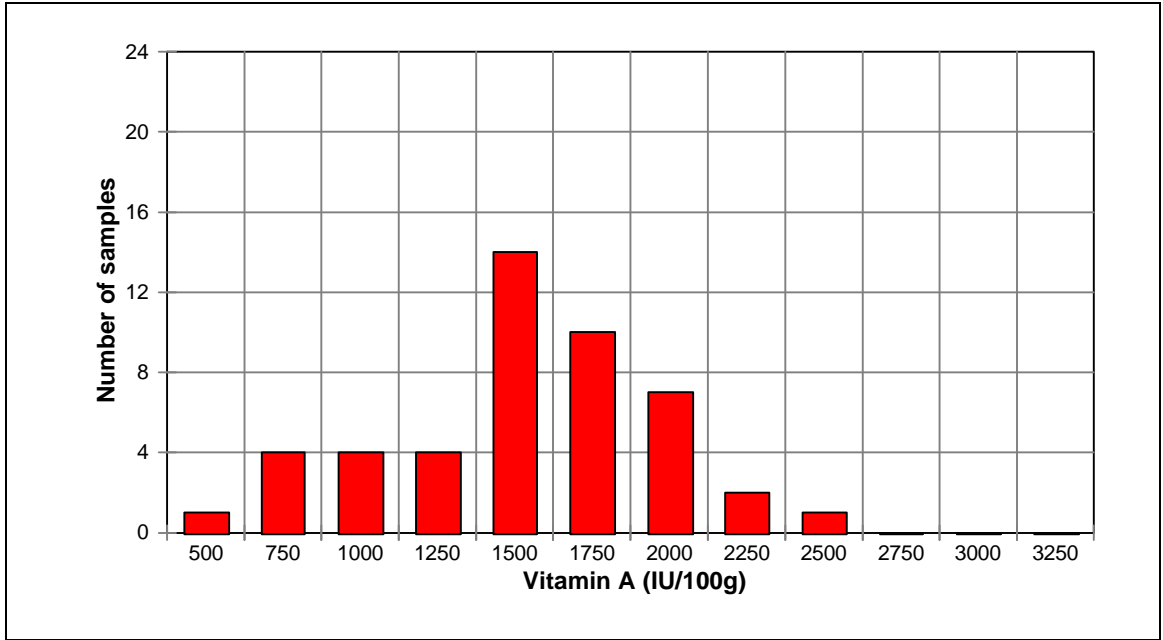


Fig. 10 - Vitamin A in CSB at Plant D

Histogram



Control Chart

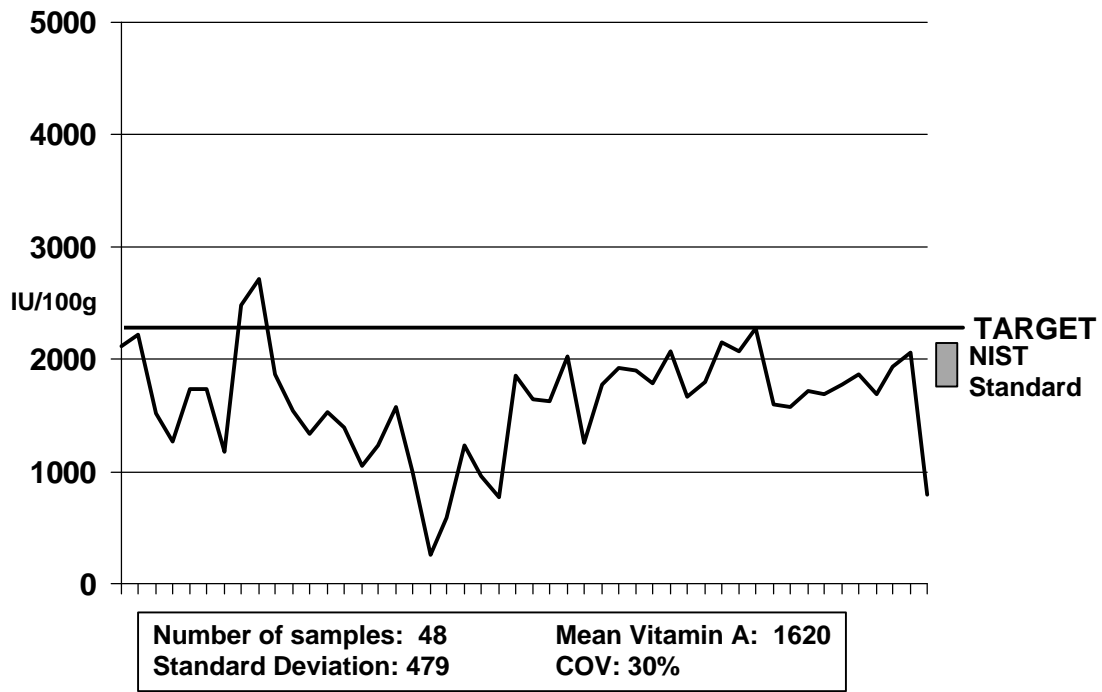
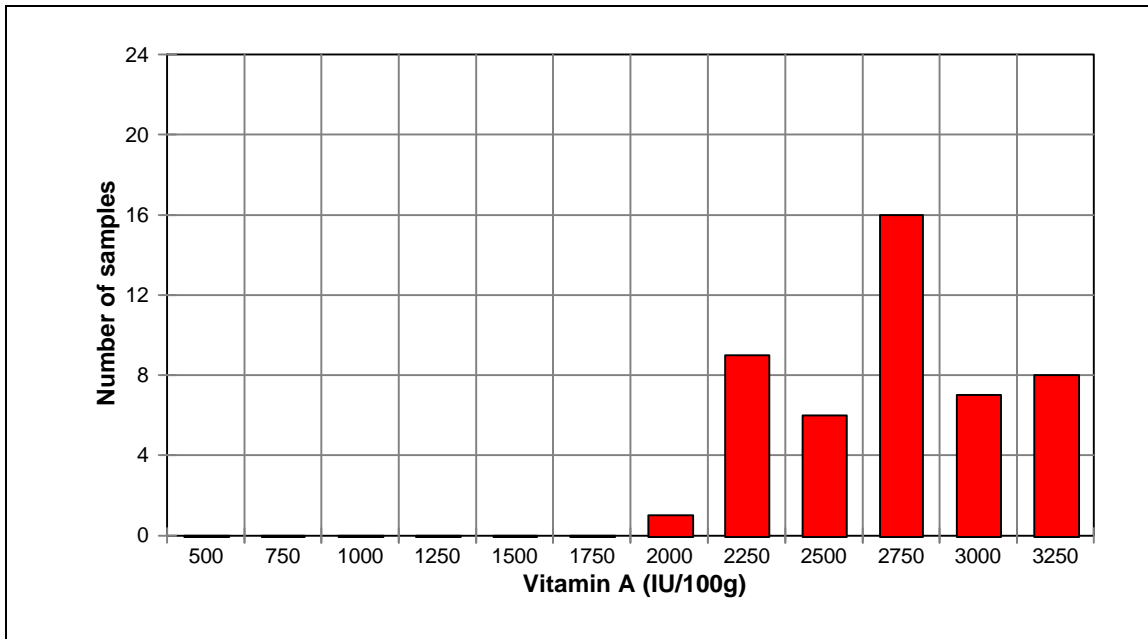


Fig. 11 - Distribution of Vitamin A in CSB at Plant E

Histogram



Control Chart

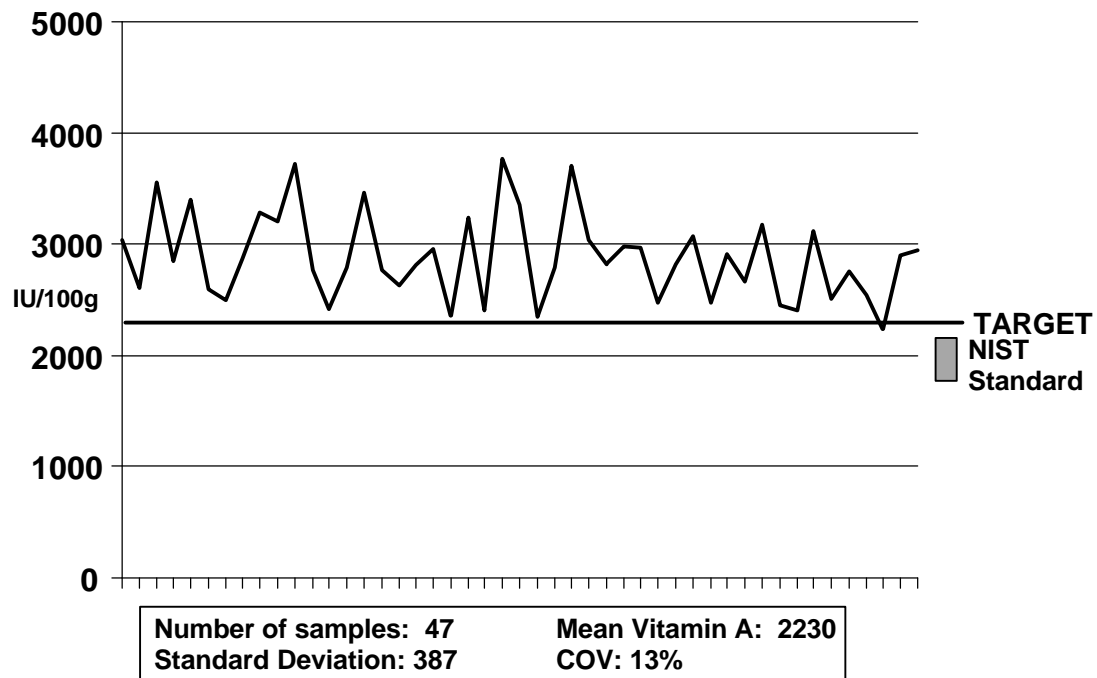
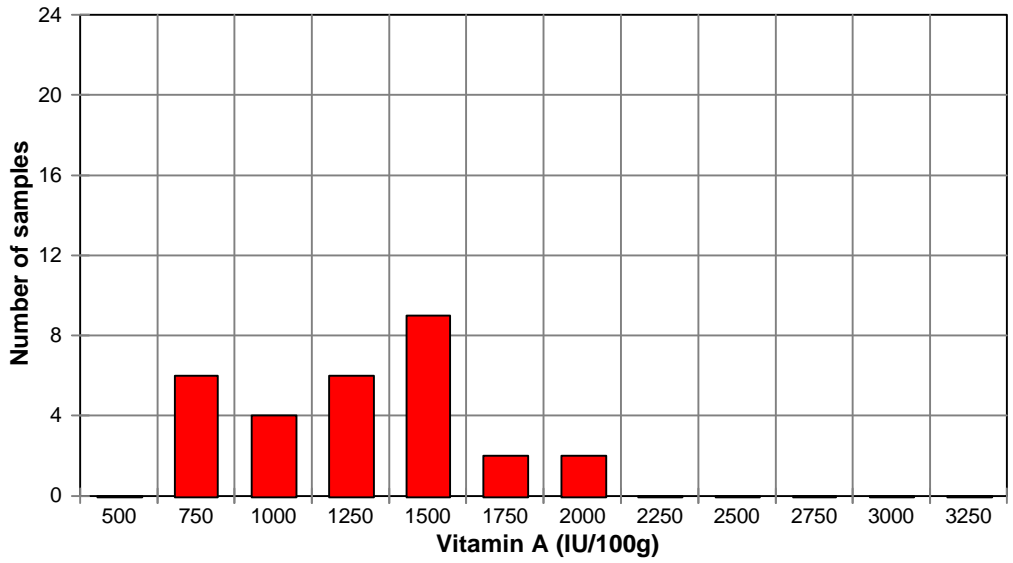


Fig. 12 - Vitamin A in Wheat Flour at Plant F

Histogram



Control Chart

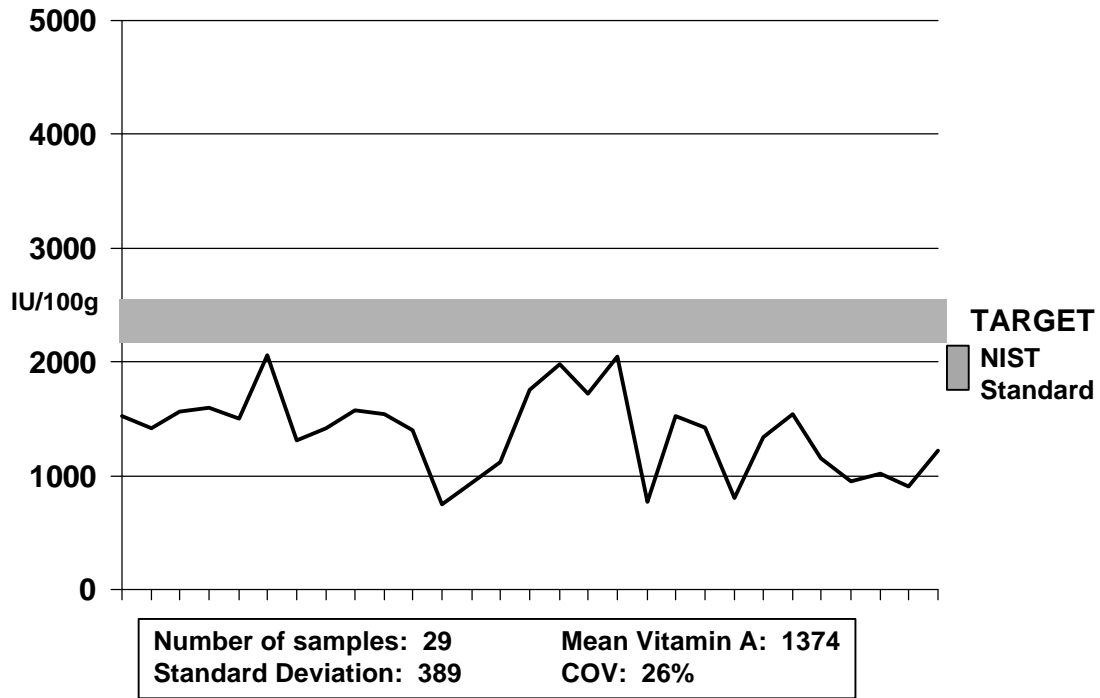
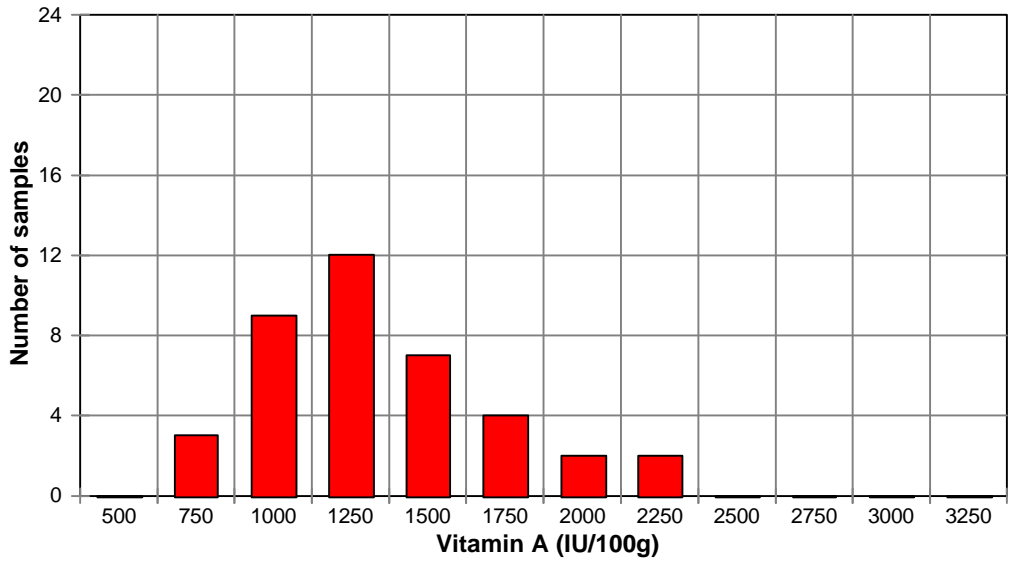


Fig. 13 - Vitamin A in Soy Fortified Bulgur at Plant G

Histogram



Control Chart

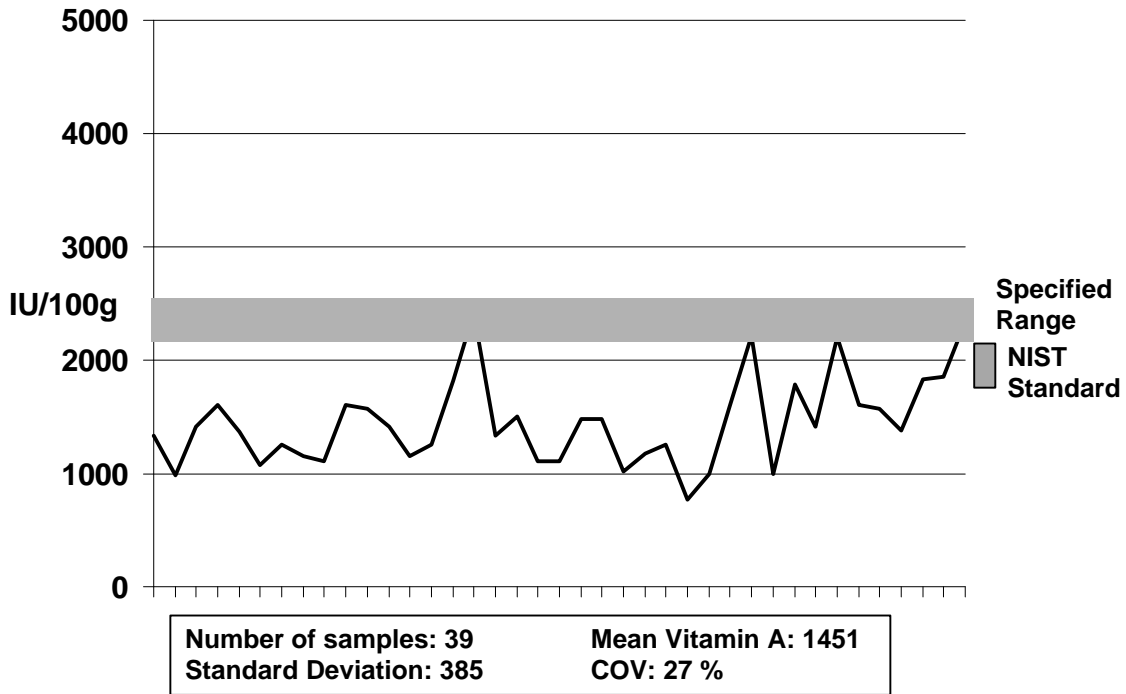
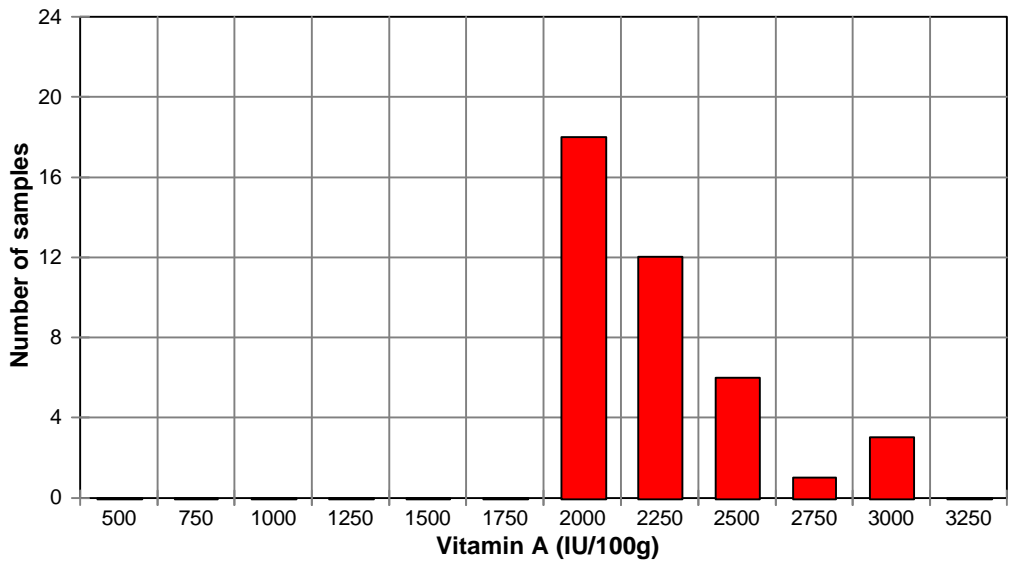


Fig. 14 - Vitamin A in CSB at Plant H

Histogram



Control Chart

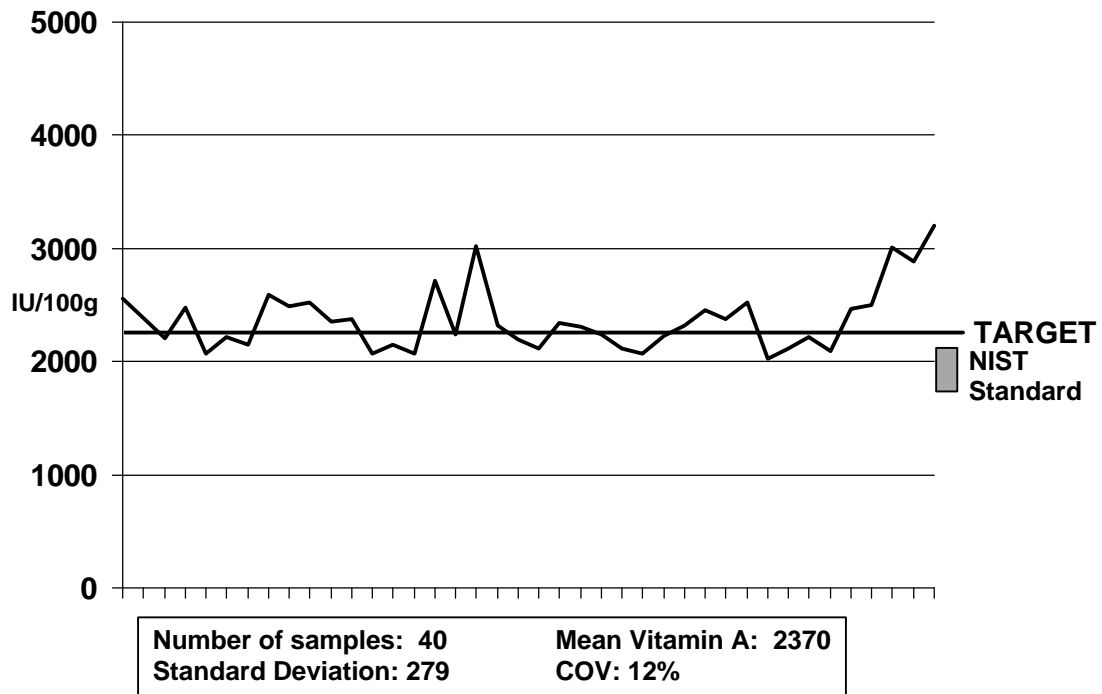
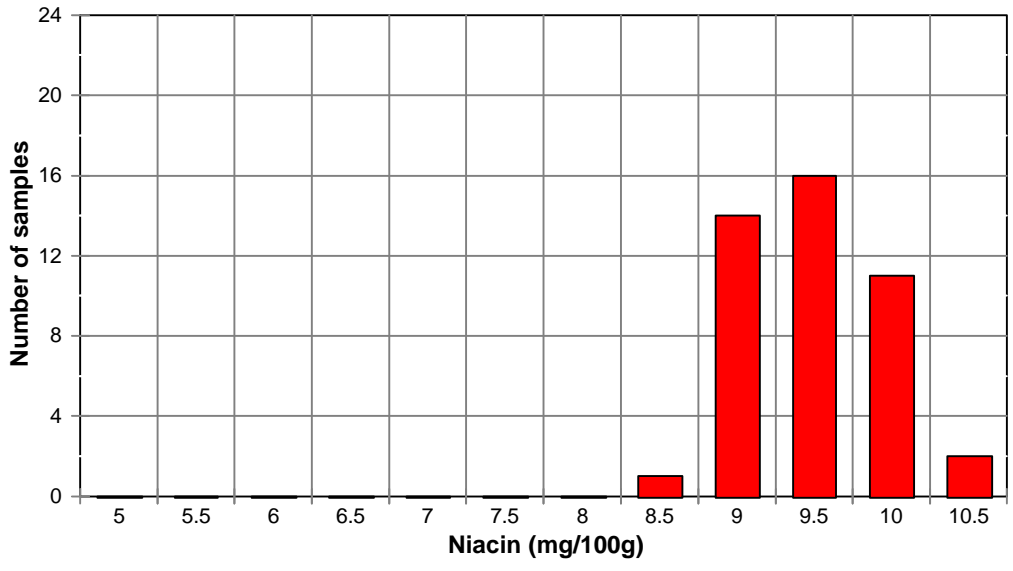


Fig. 15 - Niacin in WSB at Plant B

Histogram



Control Chart

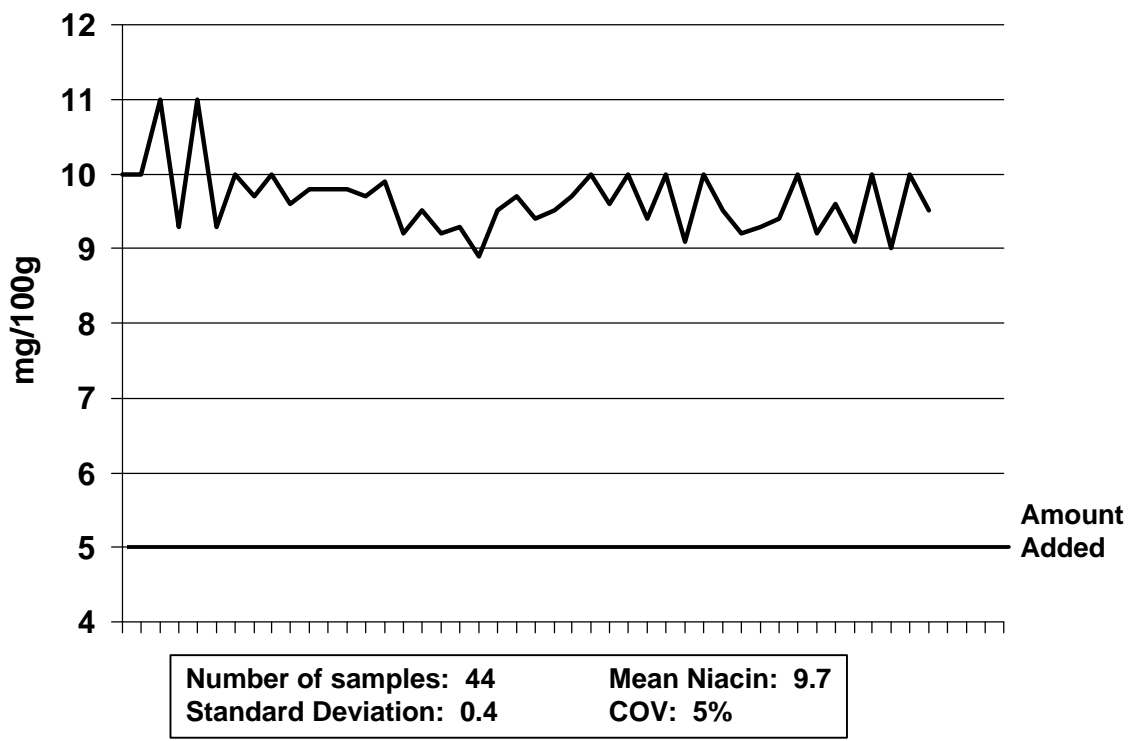
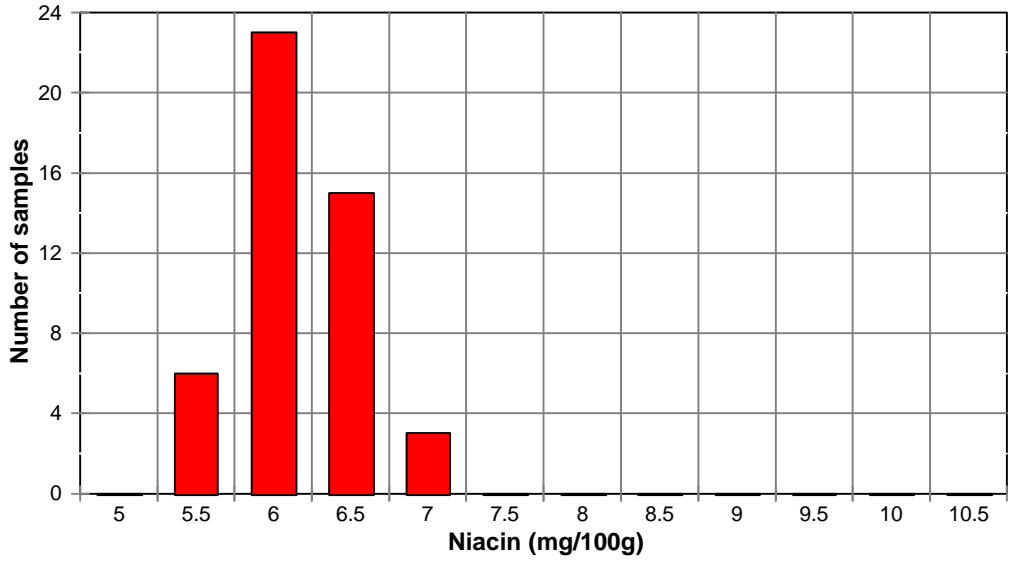


Fig. 16 - Niacin in CSB at Plant C

Histogram



Control Chart

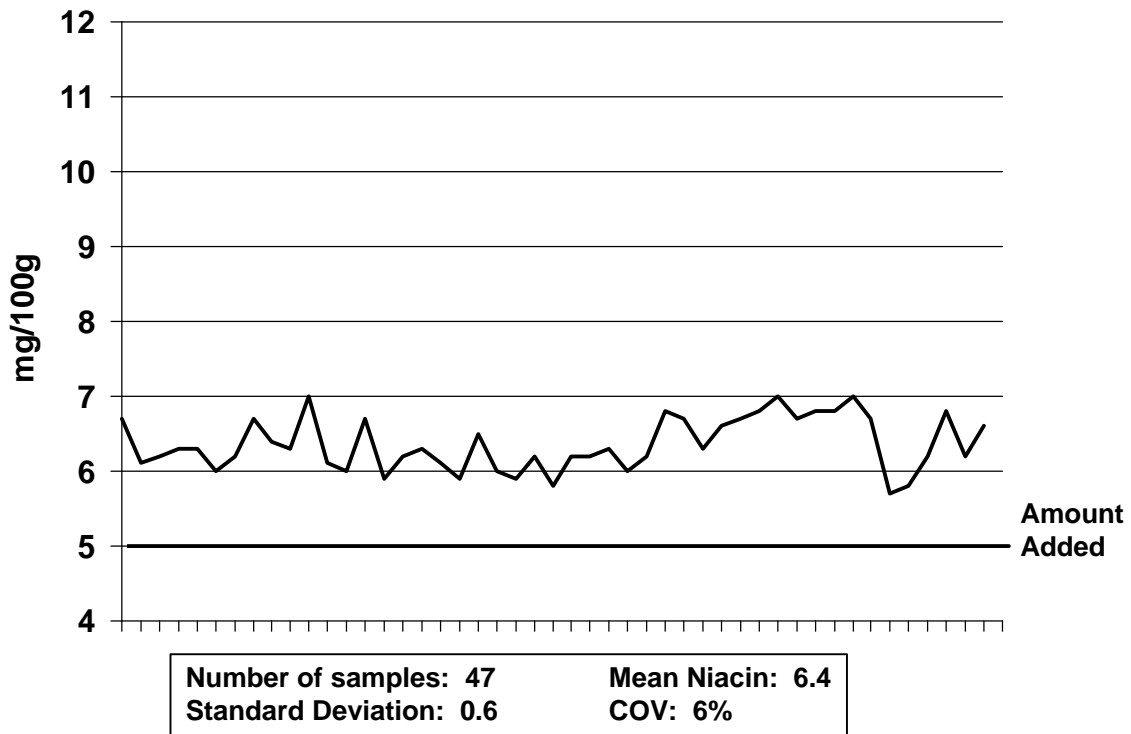
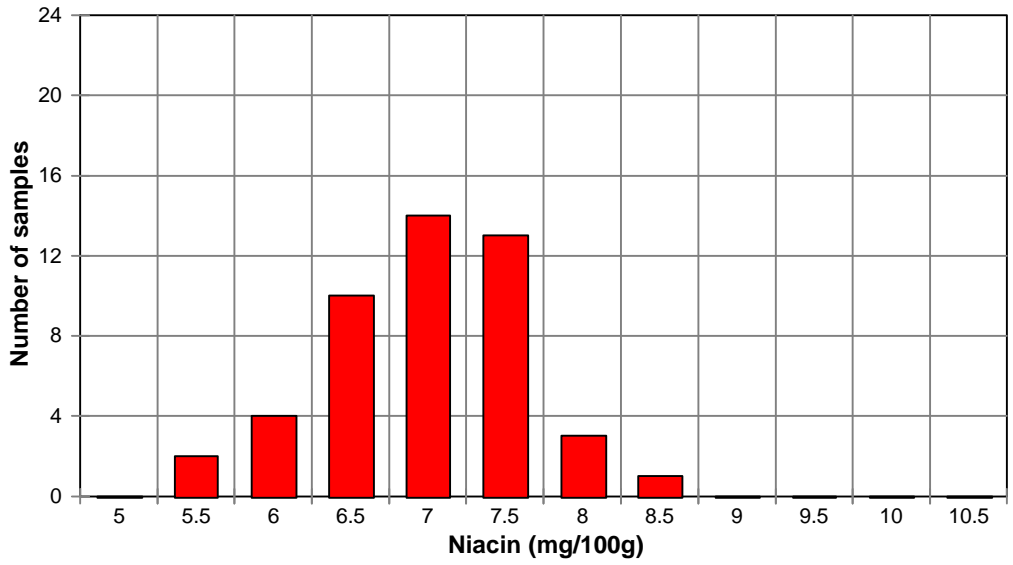


Fig. 17 - Niacin in CSB at Plant E

Histogram



Control Chart

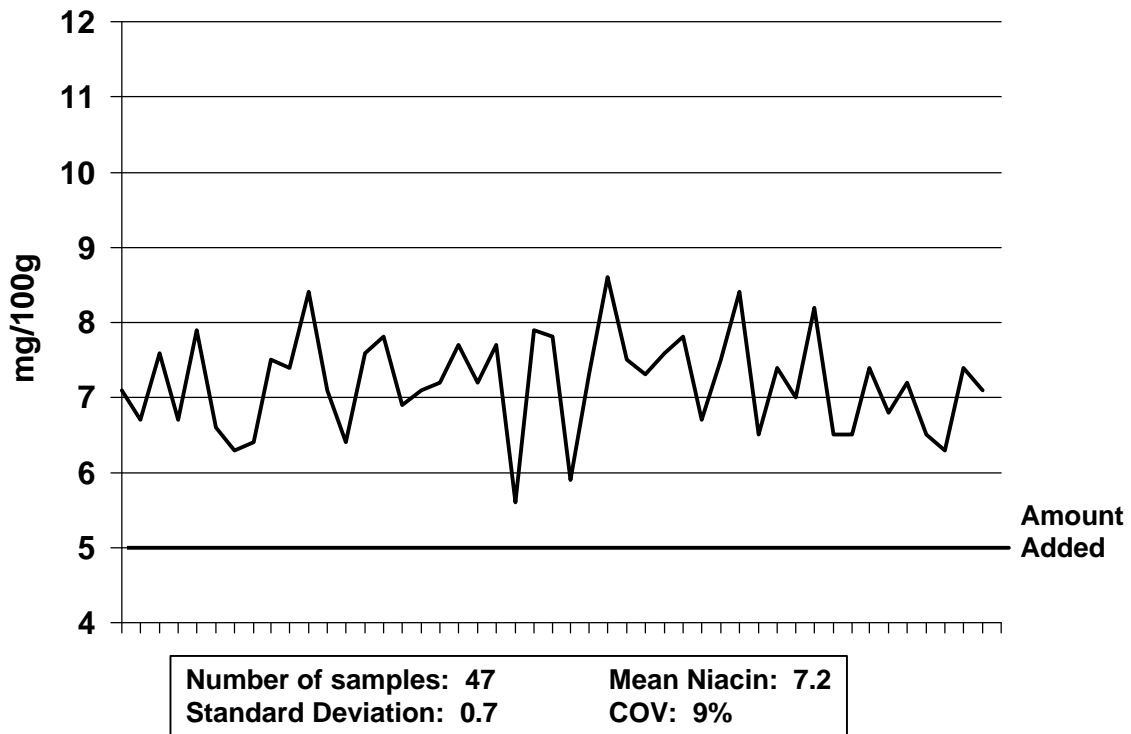
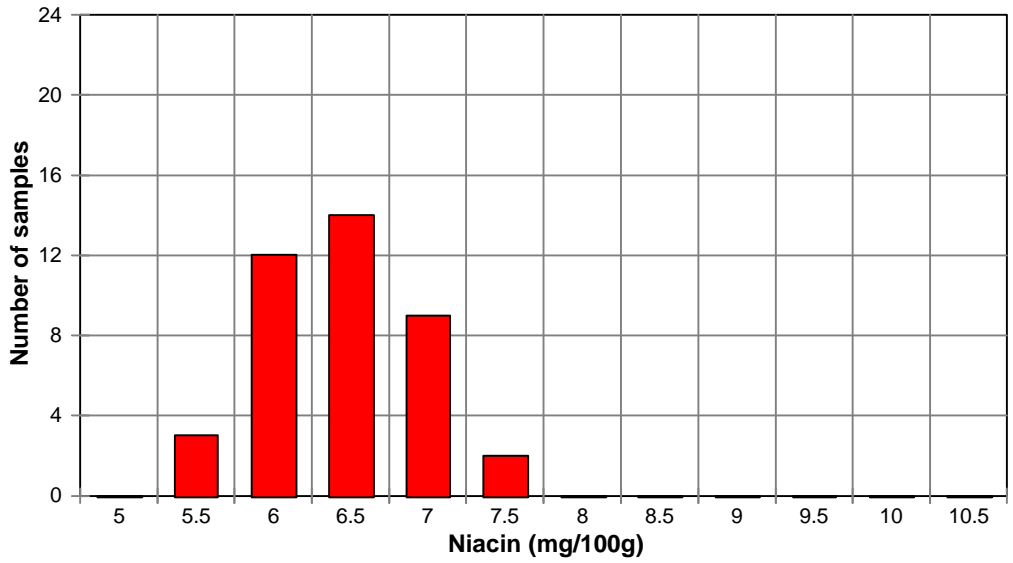


Fig. 18 - Niacin in CSB at Plant H

Histogram



Control Chart

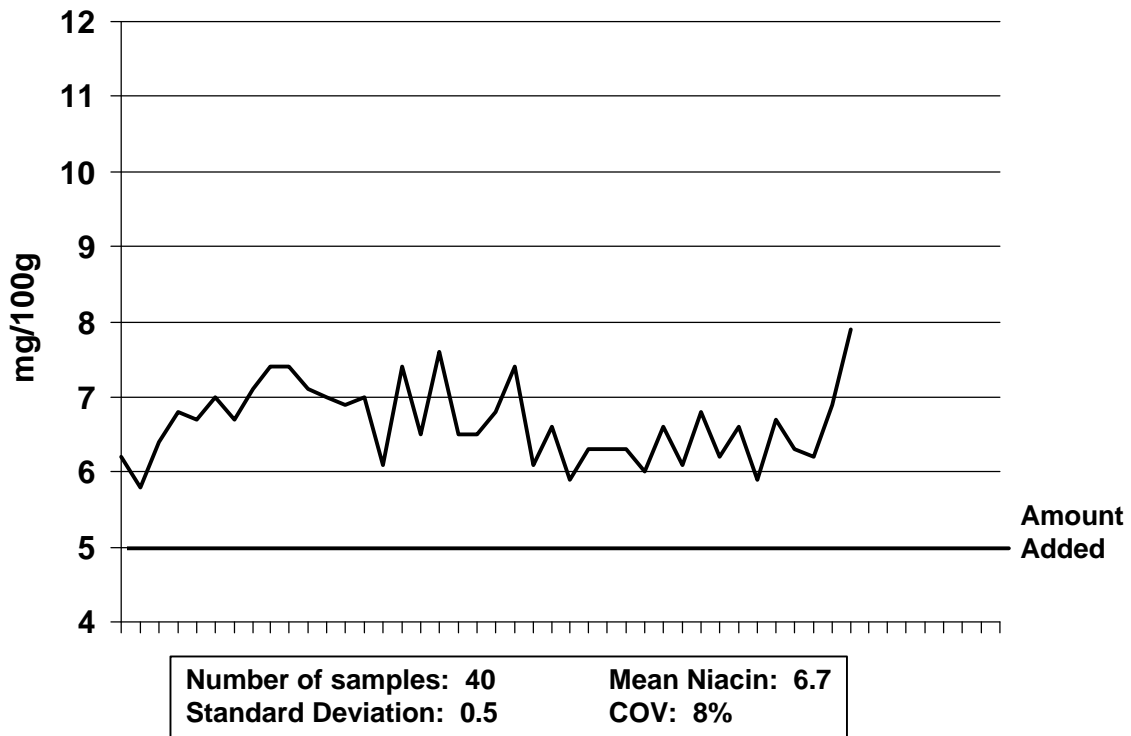
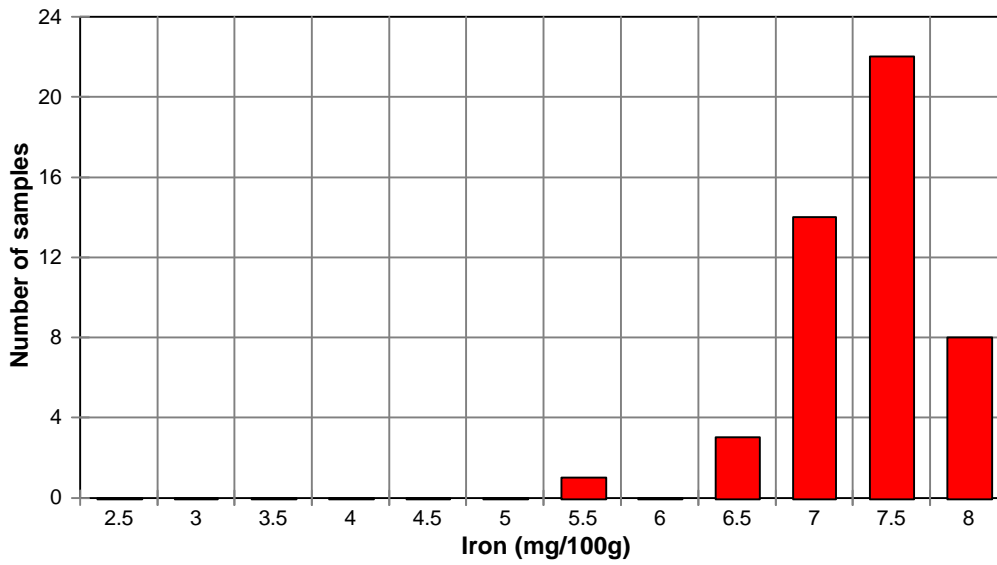


Fig. 19 - Iron in Corn Meal at Plant C

Histogram



Control Chart

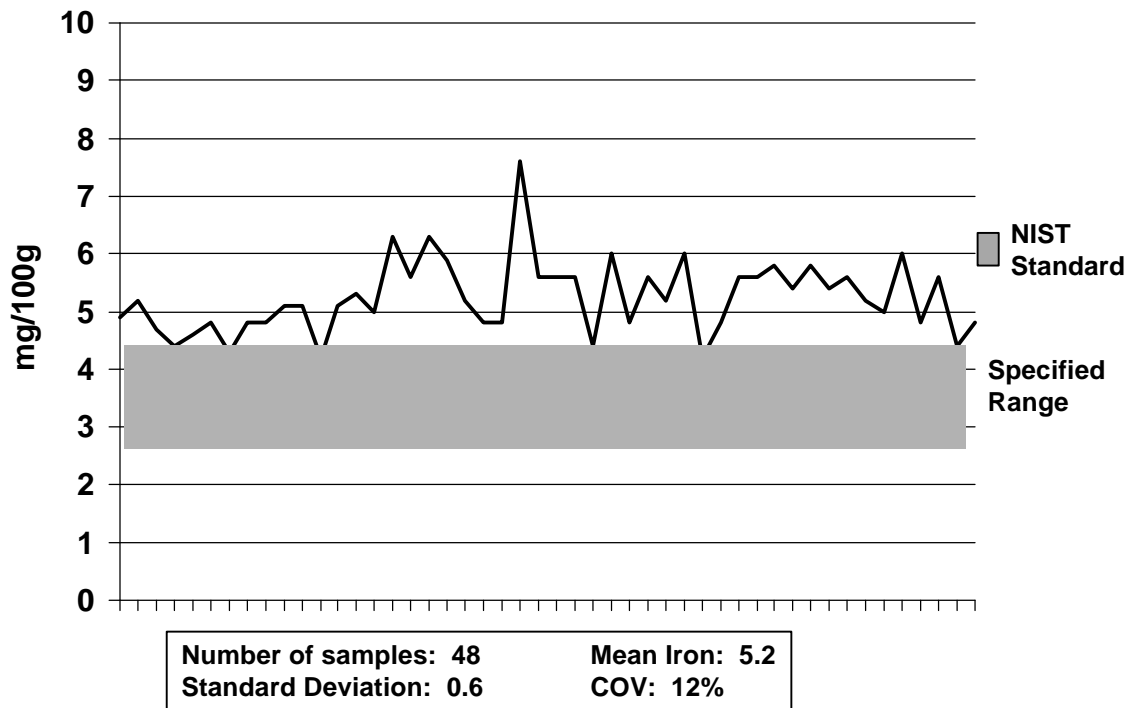
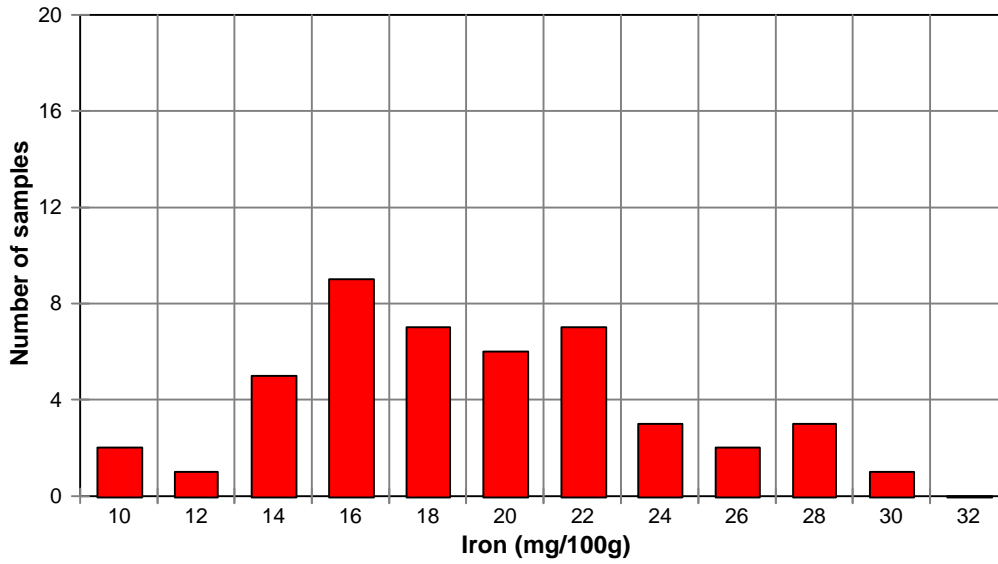


Fig. 20 - Iron in CSB at Plant C

Histogram



Control Chart

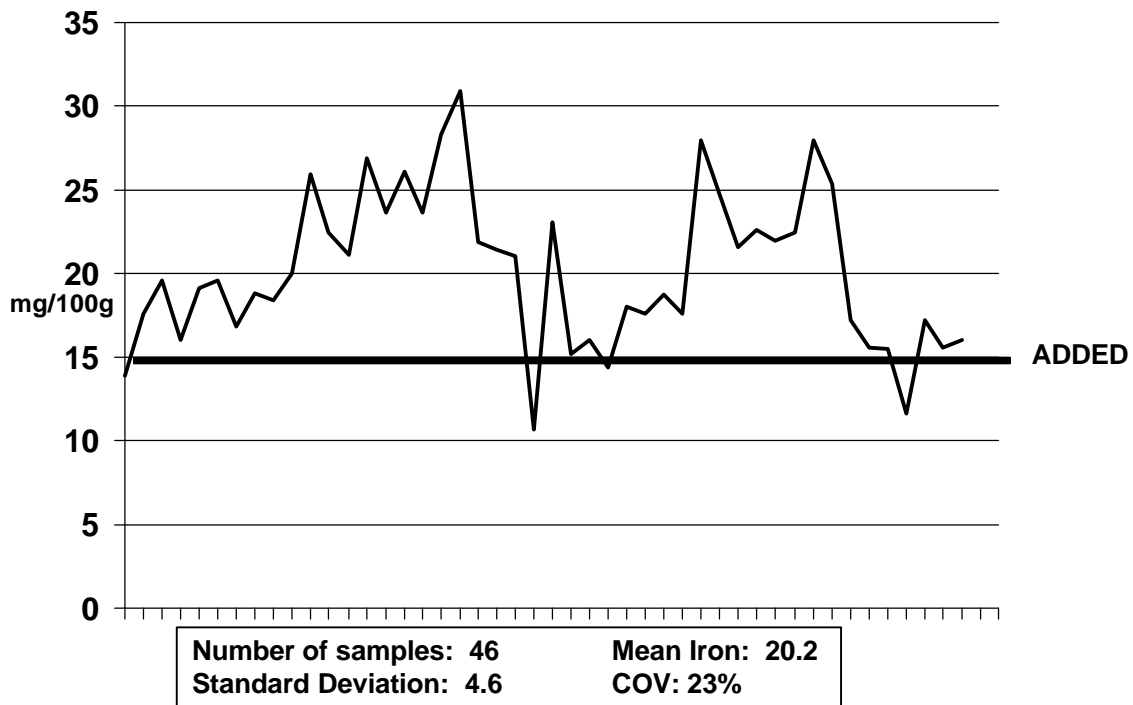
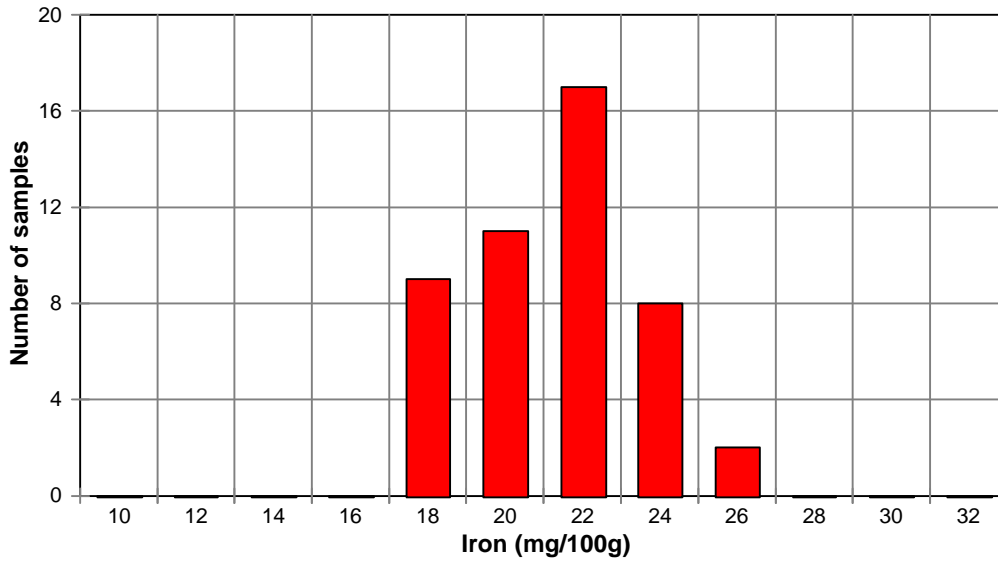
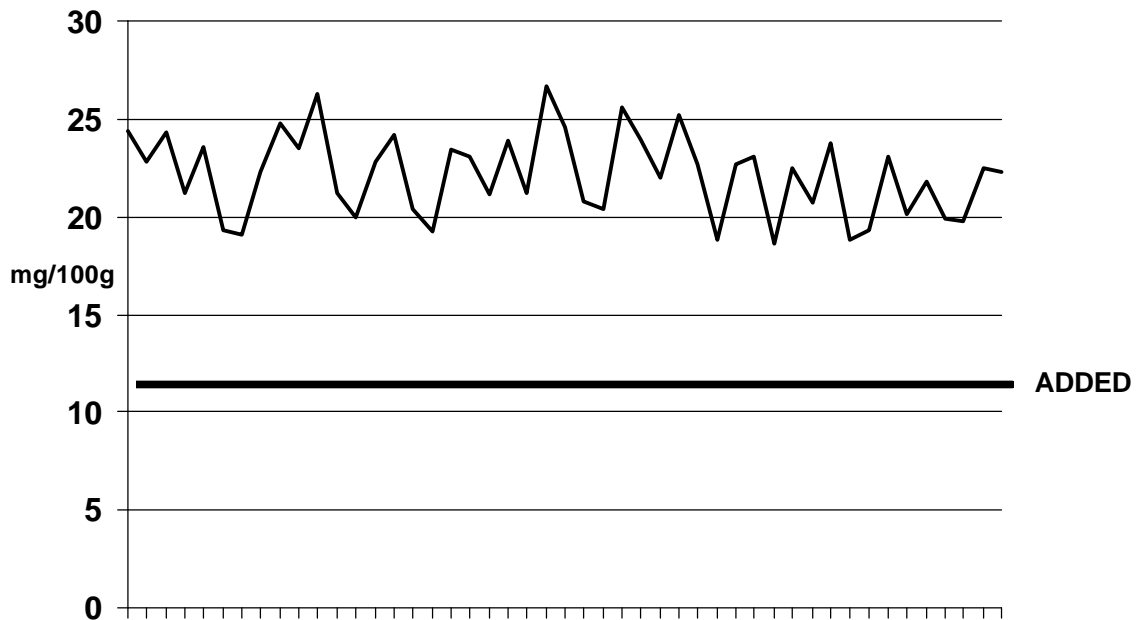


Fig. 21 - Iron in CSB at Plant E

Histogram



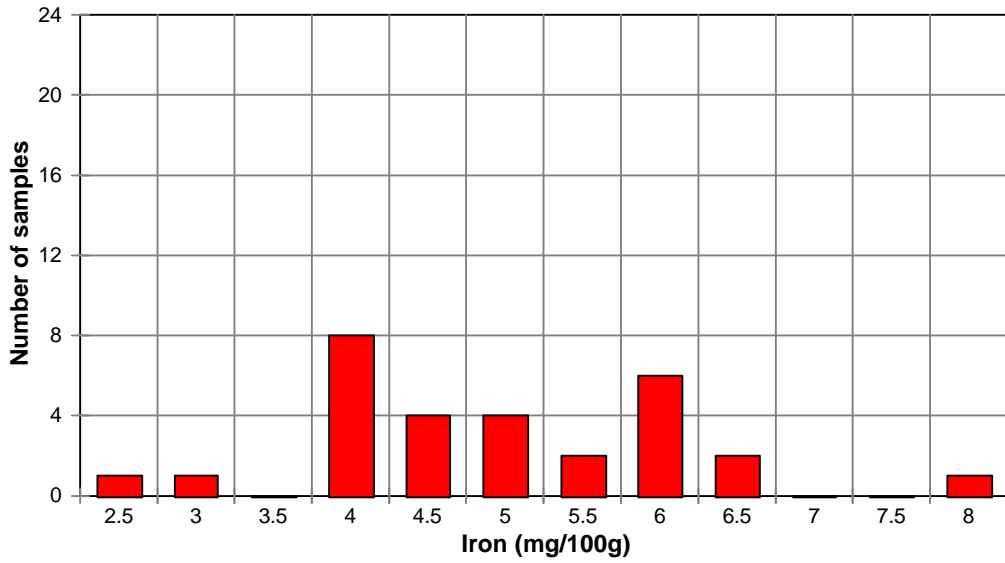
Control Chart



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

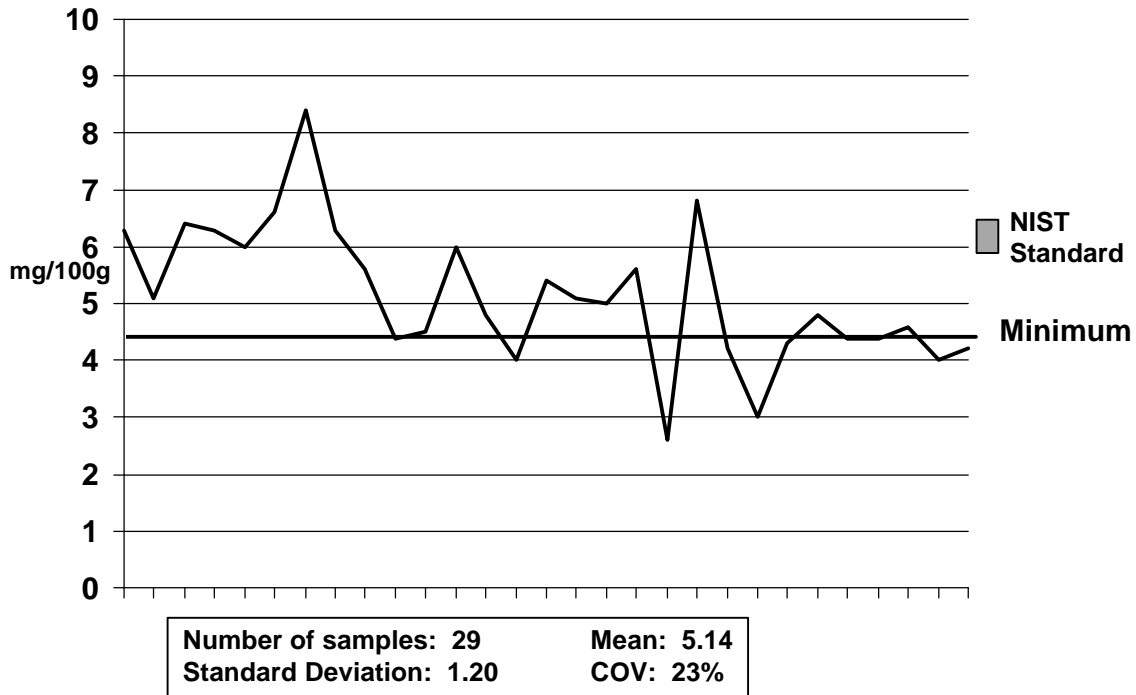
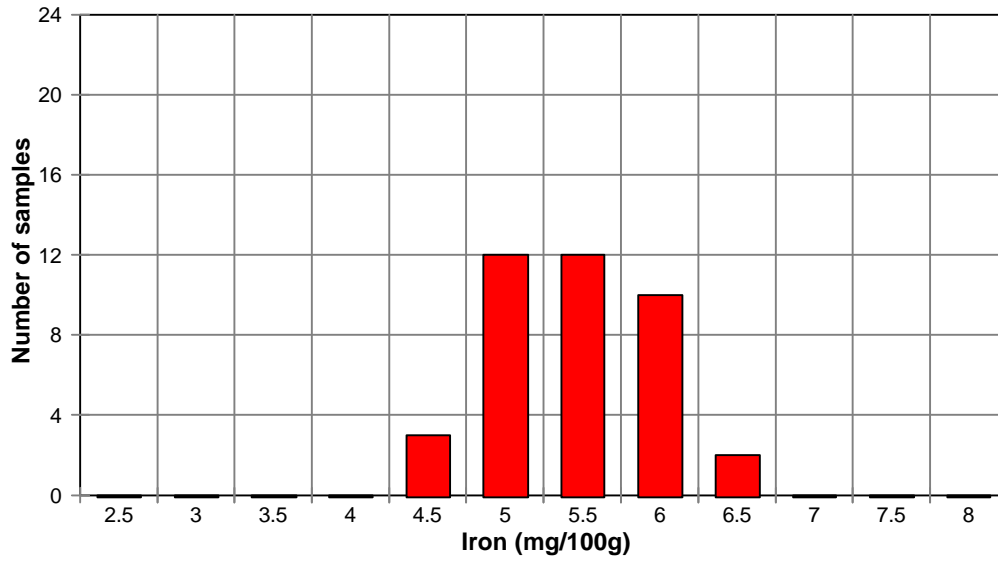


Fig. 23 - Iron in Soy Fortified Bulgur at Plant G

Histogram



Control Chart

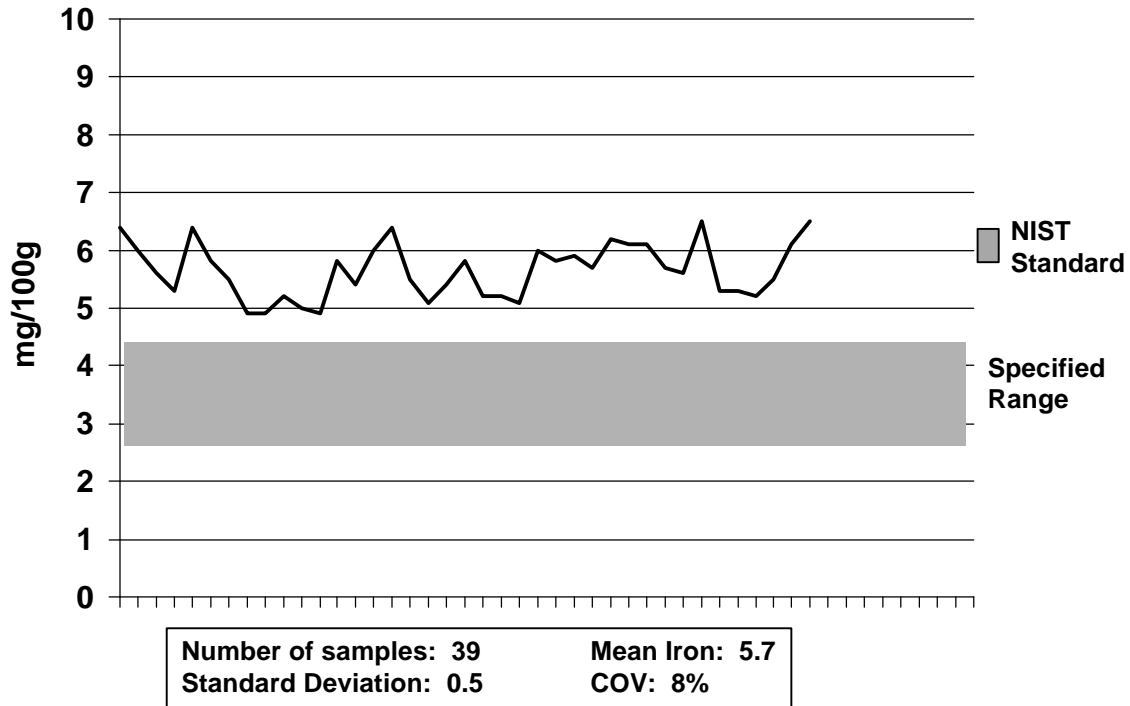
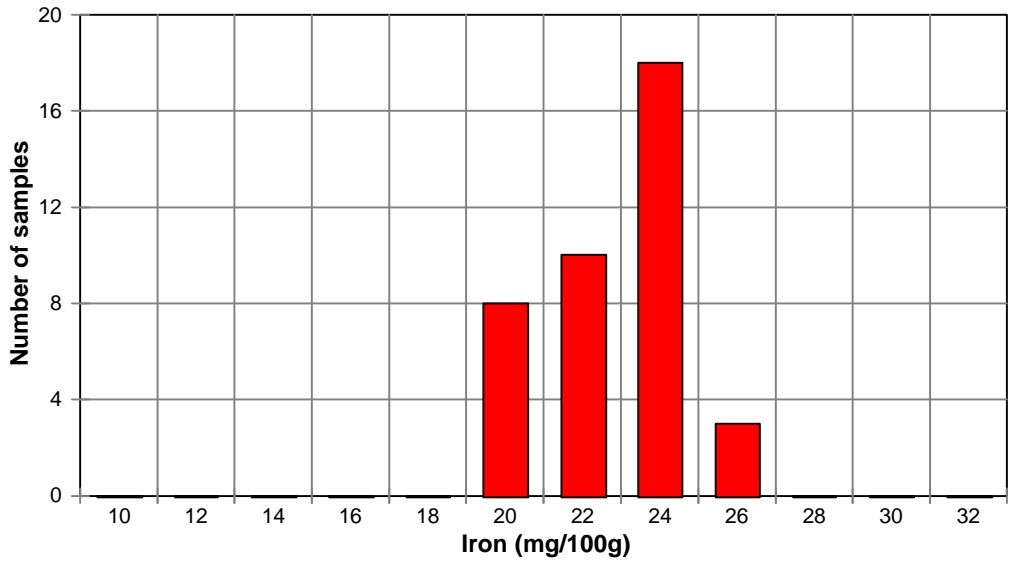
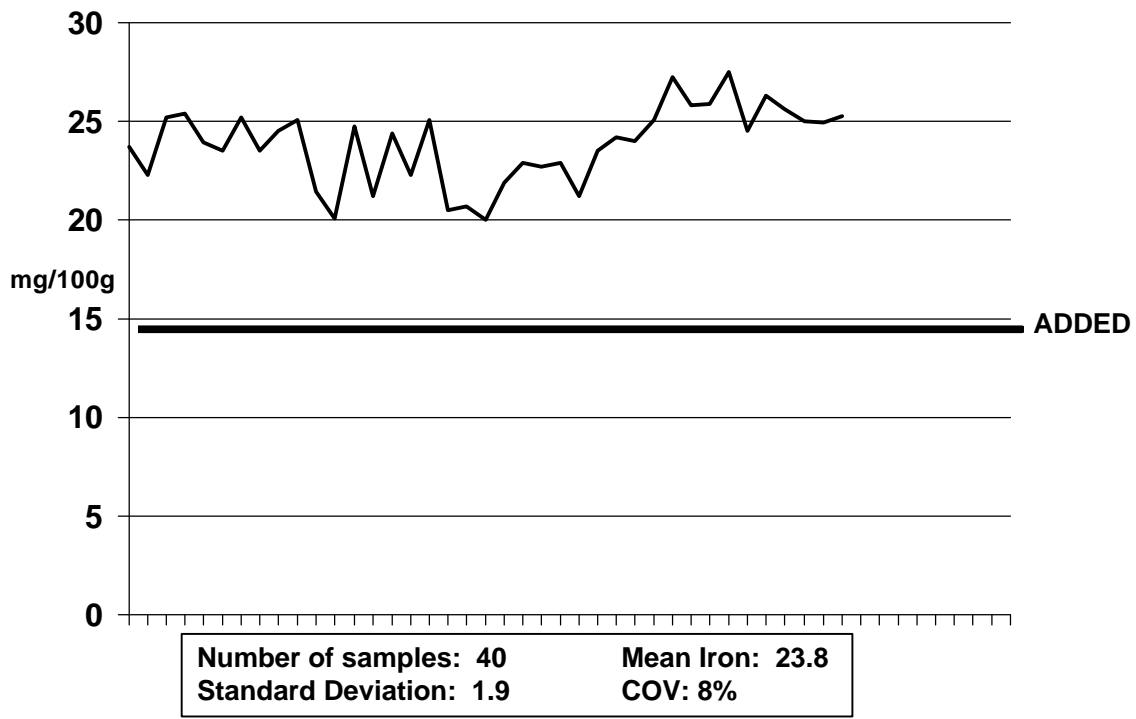


Fig. 24 - Iron in CSB at Plant H

Histogram



Control Chart



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%

<u>Ingredient</u>	<u>Amount per 2 lbs.</u>	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

<u>Ingredient</u>	<u>Concentration in Premix %</u>	Level Added	<u>units</u>
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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*Unless otherwise noted, persons consulted are located in the greater Washington, DC area.

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)³ 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.

Legislative Mandates

Several aspects of the P.L. 480 legislation specifically affect Title II, the commodity mix (e.g., whether whole grain/unprocessed, value-added⁴, bagged or bulk) and how commodities are

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)

³ 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.

⁴ Value-added commodities include those that are blended, fortified and/or otherwise processed.

programmed (e.g., in emergency, non-emergency⁵, 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 targets⁶. 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.⁷ 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 programs⁸. 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 estimates⁹.

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. 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).

⁵ Non-emergency activities are also called development activities in this report.

⁶ 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.

⁷ The preliminary estimates from USAID/BHR/FFP.

⁸ 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.

⁹ 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.

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 fraction 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 must be kept separate prior to blending into the product.

Table 2. P.L. 480 Title II Fortified Foods

Commodity Cost	Quantity Provided	Average	Value
	During FY 1997 (1,000 Metric Tons)	Cost ¹⁰ (\$/MT)	(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 ¹¹	
	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 ¹²	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 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 Tables¹³.

¹⁰ Average delivered cost including freight.

¹¹ 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.

¹² See Appendix G for composition of premixes.

¹³ Handbook 8, 1997 version; Drake, 1989

Table 4 Nutritional Composition of PL480 Commodities (per 100g)

(Source: 1989 CRG Food Commodity Fact Sheets)

Nutrient	Unit	Corn			Soy Fort		Soy Fort		Soy Fort		Wheat	
		Bulgur Wheat	Corn Meal	Soy Blend	Rice	Bulgur Wheat	Corn Meal	Sorghum Grits	Sorghum Grits	Veg. Oil	Wheat Flour	Soy Blend
		BW	CM	CSB	Rice	SFBW	SFCM	SFSG	SG	Vegoil	WF	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.

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 Standards¹⁴ 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 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.

¹⁴ Single values indicate a minimum with overages left to good manufacturing practices. Two values separated by a dash (-) indicate a minimum - maximum allowable range.

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 B ₁₂	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

<u>Ingredient</u>	1998 Estimated Cost ¹⁵ \$/MT CSB/WSB
<u>Vitamins</u>	
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
<u>Minerals</u>	
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.

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.”

¹⁵ 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.

Most commercial sources of vitamin A include antioxidants (BHT, BHA or tocopherols) to prevent them from 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 Project¹⁶.

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.

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”¹⁷. 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.

¹⁶ Ranum P. M., Chome F. Results Report on the Vitamin C Pilot Program. . Washington, DC: SUSTAIN, 1998.

¹⁷ These letters are a commodity code and not an abbreviation.

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, 9 samples are collected per car giving 36 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 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.