FINAL REPORT ON DEVELOPMENT OF AN EMERGENCY FOOD PRODUCT

PRODUCT AND PACKAGING SPECIFICATIONS, SHELF LIFE STUDY AND DROP TEST SYNOPSIS

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DISCLAIMER

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TABLE OF CONTENTS

I. BACKGROUND 8-11
A. History 8
B. Chronicle of Product Development 9

II. PRODUCT FORMULAS 11-13
A. HTST Extrusion Formulas 11
B. Bar Formulas (A-28, A-29) 11
C. Paste Formula (A-20) 12
D. Vitamin and Mineral Premix Requirements 13

III. PROCESSING PROTOCOLS 14-16
A. Bar Variables (A-28 and A-29) 14
1. Precooking and Grinding of Cereal Portion 14
2. Mixing Procedure for Bar Production 14
3. Bar Compression and Production 15
4. Qualitative Assessment of Bar Functionality 15
B. Paste Variable (A-20) 15
1. Mixing Procedure 15
2. Fill Procedure 15
C. Nutrient Requirements 16
D. Final Product Description 16

IV. PACKAGING SPECIFICATIONS 17-25
A. Paste (A-20) 17
B. Bars (A-28 and A29) 18
C. Quality Assurance Provisions Applicable to Paste Tubes/Pouches 19
D. Quality Assurance Provisions Applicable to Bars' Brick Pack Pouches 21
E. Packaging Requirements and Quality Assurance Provisions for Dehydrated Product in a Brick Pack Pouch 24

ATTACHMENT I: RESULTS OF SIX MONTHS @ 100ºF AND 24 MONTHS@ 80ºF SHELF-LIFE STUDIES WITH VITAMIN AND MINERAL PREMIX RECOMMENDATIONS

I. METHODS 25

II. RESULTS 25-27
A. Summary of the Six-Month, 100ºF Nutrient Stability Tests 25
1. Oxidation Results 25
2. Vitamin A Stability Results 25
3. Vitamin C Stability Results 25
4. Vitamin B_1 Stability Results 26
B. Summary of the 24-Month, 80ºF Nutrient Stability Test 26
1. Vitamin A Stability Results 26
2. Vitamin C Stability Results 26
3. Vitamin B_1 Stability Results 26
C. Basis for Vitamin-Mineral Premix Recommendations 26
D. Summary of Vitamin-Mineral Premix Changes 26
E. Summary of Product Macronutrient Analysis 27
F. Summary of Textural Analysis of Bars 27
G. Summary of Organoleptic Changes during Storage 27

III. CONCLUSION 28
IV. TABLES 29-34

V. FIGURES 35-42

ATTACHMENT II: FINAL DROP TEST SYNOPSIS..... 43-47

I . TYPES OF DROP TESTS PERFORMED..... 43-46
A. Simulated Low-Velocity Drop Tests (NSRDEC) 43
1. Results 43
2. Recommendations 44
B. Airdrop Test (U.S. Army Yuma Proving Grounds).....45
1. Results 45
2. Recommendations 46

ATTACHMENT III: SCOPE OF WORK 47-53

GLOSSARY

CFD	Combat Feeding Directorate
DoD	Department of Defense
EFP	Emergency Food Product
FANTA	Food and Nutrition Technical Assistance
IOM	Institute of Medicine
LA:LNA	Linoleic Acid:Alpha Linolenic Acid Ratio
NSRDEC	Natick Soldier Development and Engineering Center
PDCAAS	Protein Digestability Corrected Amino Acid Score
PUFA	PolyUnsaturated Fatty Acid
USAID	United States Agency for International Development

I. Background:

A. History

The United States Agency for International Development (USAID), in partnership with the U.S. Army Natick Soldier Development and Engineering Center (NSRDEC) Combat Feeding Directorate (CFD), developed three prototypes of a high-energy, nutrient-dense food, referred to as the Emergency Food Product (EFP). The EFP was developed specifically for large populations of displaced people or refugees who are on the move due to civil disturbances, natural disasters or industrial disasters. The EFP is expected to be the sole source of food during this period of transition (up to 15 days) until a more permanent food supply can be established.

In accordance with a Reimbursement Agreement between USAID and NSRDEC, several EFPs were co-developed by the two entities. The products were designed to provide humanitarian relief to satisfy the projected nutritional needs of mobile refugee populations. These EFPs were designed to have a shelf life—without refrigeration—of at least 24 months at 70ºF.

The CFD was tasked with developing three prototype rations with nutritional and performance requirements approved by USAID project representatives. The aforementioned requirements were modeled after the Institute of Medicine's publication for a *High-Energy, Nutrient-Dense Emergency Relief Food Product*.[1] Each of the prototypes conformed as closely as possible to the requirements outlined in the publication; they were not, however, identical, since USAID approved slight deviations, discussed in section III, subsections D and E, to better accommodate the nutritional needs of refugee populations.

Two of the prototype food products are in the form of bars, similar to the Norwegian product BP-5 (Compact), and one is a paste or semisolid emulsion/dispersion that resembles the French product Plumpy'Nut (Nutriset). The bars are grain-based rations that have been compressed into easy-to-consume rectangular bars that can also be crumbled up, dispersed in water and served as a porridge or gruel. The paste was developed to be consumed as is, right out of the pouch.

Production-scale test quantities of a dairy-based, nutrient-rich paste (A-20) and two varieties of fortified, grain-based, compressed bars (A-28 and A-29) were produced by Datrex, Inc. of Kinder, Louisiana. USAID requested two shelf stability tests to be conducted by Natick on the three production variables. The final report on the shelf stability test is included in this report as is the report on the drop tests that were carried out. FANTA conducted consumer tests of the three variables (non-stressed) in Bangladesh, Ethiopia and Nicaragua. A final report was issued June 5, 2005[2].

The following report includes formulas, processing/packaging specifications, product identification and results of nutrient stability, macro/micro analysis, textural analysis and organoleptic evaluations performed at the U.S. Army NSRDEC's Combat Feeding Directorate. Recommended changes were made to the vitamin/mineral premix based on these results. In addition, as part of the evaluation of the products, USAID requested a determination of the airdrop survivability of the three products, in the event that air delivery were the only safe means to expeditiously provide relief to

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[1] Subcommittee on Technical Specifications for a High-Energy Emergency Relief Ration, Committee on Military Nutrition Research. *High-Energy, Nutrient-Dense Emergency Relief Food Product (2002)* may be downloaded free from: **National Academy Press, 2101 Constitution Avenue, NW, Lockbox 285, Washington, DC 20055, telephone (800) 624-8373 or (202) 334-3313, Fax (202) 334-2451. Internet address: http://www.nap.edu/catalog.php?record_id=10347**

[2] Chris Moessner, Sarah Fulton, Brian O'Meara and Amie Kim. *Assessment of an Emergency Food Product.* Washington, DC: Food and Nutrition Technical Assistance Project, 2005

the refugee populations 'on the move'. The synopsis of those results are included in this report as well.

B. Chronicle of Product Development

2001:

1. The Committee on Military Nutrition Research and the Food and Nutritional Board of the Institute of Medicine (IOM) convened to develop technical specification for a "High-Energy, Nutrient-Dense Emergency Relief Food Product." The results from the committee have been published[3].

2002:

1. Based on the Institute of Medicine's (IOM) outline of the desirable EFP characteristics, the DoD's Combat Feeding Directorate entered into a contractual agreement with USAID to develop three EFP prototypes for commercial production (two metric tons of each variable), field evaluation (testing of prototypes to target ethnic populations), nutrient and shelf life studies, low-velocity airdrop testing and development of technical specifications for USDA procurement (see Attachment 3).
2. September 30: Interagency agreement was signed and timelines for project were established.
3. December 5: CFD representative presented to USAID program officers a detailed description of prototypes, processing schematics and packaging configurations for the EFP, which were under development at Natick.

2003:

1. January 23: USAID representatives visited CFD to evaluate prototype rations, evaluate proposed packaging configurations, select the most functional design and address vitamin and mineral fortification.
2. January 30: USAID developed initial vitamin and mineral premix requirements. CFD collaborated with a commercial vendor to produce a proprietary premix formulation for use in EFP prototypes.
3. April 11-12: CFD representatives traveled to Washington D.C. to present six prototypes—baked, kettle-cooked, and high temperature short time (HTST) cooking extrusion—for USAID to evaluate and select three variations. USAID and CFD also engaged in a roundtable discussion regarding the feasibility of producing a non-genetically modified organism (GMO) EFP prototype.
4. April 23: USAID chose three variables (rice-based bar, wheat-based bar, and a squeezable paste) for testing. The HTST pre-cooking of the grains procedure was chosen as it best preserves the vitamins. USAID requested development of a non-GMO EFP variable along with cost analysis on said variable.
5. April 28-May 1: USAID nutritional advisor visited CFD to assist in the fine-tuning of selected variables and cost analysis of developing a non-GMO EFP.
6. May 13: A GMO-free product was developed at a cost 40 percent higher than the current prototypes.
7. May 22: It was determined that a GMO-free ration could not be procured due to price constraints. USAID stated that only the protein need be GMO-free.
8. June 4: Final product selections were determined (two compressed bars—rice-based and wheat-based—and one paste variable were chosen) and final adjustments in the vitamin and mineral fortification premix were made by USAID's nutritional advisor. Packaging configurations for bars and paste were also finalized.

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[3] Subcommittee on Technical Specifications for a High-Energy Emergency Relief Ration, Committee on Military Nutrition Research. *High-Energy, Nutrient-Dense Emergency Relief Food Product (2002)* may be downloaded free from: **National Academy Press, 2101 Constitution Avenue, NW, Lockbox 285, Washington, DC 20055, telephone (800) 624-8373 or (202) 334-3313, Fax (202) 334-2451. Internet address: http://www.nap.edu/catalog.php?record_id=10347**

9. July 31: The completion date was extended through no-cost agreement from September 30, 2003 to September 30, 2004.
10. September 24: Pilot-scale extrusion run was conducted at Kerry Foods Inc., and the extruded/ground precooked grain base was shipped to Datrex Inc. for pilot-scale compression and bar production. Test variables were shipped back to Natick for evaluation.
11. November 26: EFP box design was completed and approved by USAID.

2004:

1. February 18: CFD personnel attended extrusion of cereal production run at Kerry Foods Inc. in Omaha, Nebraska. Over 7,000 lbs. of grain-based extruded/ground products were produced to serve as a base for the EFP bars, which were produced later in the year.
2. June 21-25: CFD personnel attended EFP production run at Datrex Inc. in Kinder, Louisiana to produce six metric tons of EFP (three variables: two metric tons each). This production test was performed to optimize parameters to ensure contract specifications could be met for the large-scale production run.
3. July 1: EFP paste prototypes were well received by USAID representatives. EFP bar prototypes were not as firm as anticipated; the lot was rejected by USAID. The texture problem was determined to be caused by extrusion and grinding variances which resulted in a powdery product that did not compress firmly.
4. July 2: USAID authorized an additional EFP production of the bars.
5. July 28-29: CFD personnel were present at Kerry Foods for the second production of the extruded EFP grain-based pellets. Extrusion parameters were adjusted to obtain a suitable product.
6. August 11-13: Extruded EFP pellets were received at CFD. The pellets were ground in-house according to the specifications used for prototype development and shipped to Datrex for bar production.
7. August 25-26: CFD representatives attended supplemental bar production performed at Datrex, Inc. Both the rice-based and wheat-based EFP bars were highly acceptable and bar integrity was vastly improved over previous run.
8. September 1: EFP paste shelf-life studies (6 months at 100ºF and 2 years at 80ºF) were initiated to include: micronutrient viability and sensory evaluations.
9. September 27: EFP bar shelf-life studies (6 months at 100ºF and 2 years at 80ºF) were initiated to include: micronutrient viability and sensory evaluations.

2005:

1. March: USAID through FANTA conducted field assessments that were designed to evaluate the usability and favorability of the three EFP prototypes for consumption. The assessments were carried out among residents of refugee camps in Bangladesh, Ethiopia and Nicaragua.
2. July 26: CFD received FANTA report on field assessment of EFP prototypes. The results from this field test were very positive. All variables were well received with regard to taste and utility. Approximately nine in 10 adults said they liked the bar products “a lot” (rice-based bar 91% and wheat-based bar 88%). Slightly fewer adults like the paste variable (84%) “a lot.” When compared with other types of emergency food products, 82-100% of all respondents from all three countries reported that they were “Better than other foods I have been given.”
3. September 12: Interim formulas and processing specifications on all three prototypes were submitted to USAID and USDA.
4. December 6: EFP Accelerated Storage Study interim report on micronutrient stability was submitted to USAID for review. Some losses of target vitamins were reported: minor losses of vitamin C in bars; B1 in paste and a significant loss of vitamin A in the paste. USAID may need to increase fortification amounts to compensate for labile vitamin losses.

2006:

1. March 23: USDA posted Request for Information (RFI) and Sources Sought Notice for Emergency Energy Bars/Paste.
2. June 13: Simulated low-velocity airdrop was conducted by the Aerial Delivery Engineering Support Team on all three EFP products from drop tower asset at the Natick Soldier Center. All variables held up well to both drop heights of 36 and 63 feet (98-100% survivability rates).

3. July 14: Free-fall (terminal velocity) airdrop conducted in Yuma, New Mexico; results were mixed. All EFP rations were tested through the free-drop method; the paste ration suffered approximately 60% failure while the bar rations suffered significantly less when dropped in their commercial fiberboard packaging. When the EFPs were removed from their fiberboard case and dropped individually, their survivability rate was substantially greater. Both the bars and the paste rations survived with minimal damage and 100% of each was considered consumable.
4. September 27: The EFP two-year storage study was completed and final samples were sent to Eurofins for nutrient analysis.
5. November 3: Drop-test synopsis and recommendations report was generated and subsequently submitted to USAID for evaluation and feedback.
6. November 15: In-house sensory panels were performed on control samples (stored at 0ºF) and stored samples. All samples surpassed quality metrics established in reimbursement agreement with USAID.

2007:

1. January: No-cost extension was approved for final report generation.
2. January-March: Preparation of final EFP reports to include: Nutrient Shelf Life Study Report and Product and Packaging Specifications Report.
3. April 2: Submission of Final Reports to USAID.

II. PRODUCT FORMULAS

A. HTST Extrusion Formulas

INGREDIENT	Formula 8B(Rice) %	Formula 9B(Wheat) %
Rice Flour (White)	42.00	0.00
Wheat Flour (White 9-11% Protein)	0.00	42.00
Oat Flour (dehulled & kilned 9% Protein)	15.00	15.00
Potato Flour	15.09	15.09
NFDM	5.00	5.00
Whey Protein Concentrate (80% Protein)*	8.50	8.50
Sugar	5.00	5.00
Pea Protein Isolate (82% Protein)**	5.00	5.00
Soybean Oil	2.00	2.00
Lecithin (Soybean liquid)***	0.75	0.75
Salt	1.66	1.66
Total	100	100

* Recommended source: Davisco Foods International: Phone 952-941-0400
** Recommended source: Norben (Food Ingredients Group) Phone 440-951-2715
*** Use American Lecithin Co. (Alcolec BF) or equivalent.

B. Final Bar Formulas

INGREDIENT	RICE (A-28) %	WHEAT (A-29) %
Pre-cooked Cereal Mix Rice-Based Type 8B*	60.900	0.000
Pre-cooked Cereal Mix Wheat-Based Type 9B*	0.000	60.900
Sucrose (Confectioners Sugar 6x's)	10.408	10.408
Part Hydro Soybean oil **	8.016	8.016

Cream Powder (76% Butter Fat) ***	8.000	8.000
Maltodextrin DE 10 (GPC M-100 or equivalent)	6.750	6.750
Rice Syrup 26 DE (California Natural Products)****	3.000	3.000
Vit/Min Premix*****	1.420	1.420
Canola Oil	1.000	1.000
Lecithin #	0.500	0.500
Mixed Tocopherols #	0.003	0.003
BHA (Tenox 4B) ##	0.003	0.003
Total	100	100

* Type 8B and 9B pre-cooked cereals: See specifications for production of pre-cooked cereals.
**"Cream Flex 30009" from Ventura Foods, 633 South Mission Rd., Los Angeles, CA 90023 or equivalent
*** Cream Powder from Quality Ingredients Corp., 14300 Rosemount Dr., Burnsville, MN 55306 (Quali-Cream 7211) or equivalent.
**** Clarified White Rice Syrup from California Natural Products (Product code: WRSRDCL) or equivalent
***** Vit/Min Premix Fortitech or Equivalent Phone 518-372-5155
# American Lecithin Co: (Alcolec BS) or equivalent.
ChemPoint Phone 800-485-9569

C. Paste Formula (A-20)

INGREDIENT	A-20 %
Maltodextrin DE 10 (GPC M-100 or equivalent)	28.018
Soybean Oil	23.915
Confectionary sugar (6x's)	18.040
Nonfat Dry Milk Powder	11.022
Whey Protein Conc.(80% Protein)*	6.062
Cream Powder 76% Fat**	5.511
Lecithin (liquid)	2.480
Pea Protein Isolate (82%Protein)***	2.204
Vit/Min Premix Fortitech****	1.571
Salt	1.102
Sensient Colors (Brown Lake Blend R)#	0.037
Ascorbyl Palmitate	0.028
BHA##	0.005
Mixed Tocopherols##	0.005
Total	100

*Possible Source: Norben (Food Ingredients group) Phone 440-951-2715
**Cream Powder from Quality Ingredients Corp., Phone 952-250-0289
*** Possible Source: Davisco Foods International: Phone: 952-914-0400
****Vit/Min Premix, Fortitech or Equivalent Phone 518-372-5155
Sensient (Brown Lake Blend R) Contains: FD&C Yellow #5 Lake, FD&C Red #40 Lake, and FD&C Blue #1 Lake
##ChemPoint Phone 800-485-9569

D. **Vitamin and Mineral Premix Formula (Required vitamins and mineral for 500-gram bars and 450 grams of paste)**

	500 gram bars	450 grams paste	
	A-28 and A-29	A-20	
Encapsulated Vitamin A (as Palmitate, USP-FCC)	3497	3800	IU
Vitamin D3 (as Cholecalciferol, USP-FCC)	400	400	IU
Vitamin E (as acetate, USP)	30	30	IU
Vitamin K1 (as Phytonadione, FCC)	0.1	0.1	mg
Encapsulated Vitamin C (as Ascorbic Acid, USP-FCC)	280	280	mg
Encapsulated B1 (as Thiamin Mononitrate, USP-FCC)	1.7	1.8	mg
Vitamin B2 (as Riboflavin, USP-FCC)	1.8	1.8	mg
Niacin (as Niacinamide, USP-FCC)	12	12	mg
Vitamin B6 (as Pyridoxine HCl, USP-FCC)	2	2	mg
Folic Acid (USP-FCC)	0.4	0.4	mg
Vitamin B12 (as Cyanocobalamin, USP)	25	25	mcg
Biotin (FCC)	50	50	mcg
Pantothenic Acid (D-Calcium Pantothenate, USP)	7	7	mg
Calcium (as Tricalcium Phosphate, FCC)	600	600	mg
Phosphorus (as Dipotassium&Tricalcium Phosphate, FCC)	1000	1000	mg
Magnesium (as Magnesium Oxide, USP)	200	200	mg
Zinc (as Zinc Oxide, USP)	18.5	22	mg
Copper (as Cupric Oxide)	0.9	0.9	mg
Manganese (as Manganese Sulfate, USP-FCC)	0.5	0.5	mg
Selenium (as Sodium Selenate)	40	40	mcg
Chromium (as Chromium Chloride (6 H2O), USP)	25	25	mcg
Iodine (as Potassium Iodide, USP-FCC)	0.1	0.1	mg
Iron (as Iron EDTA for bars and ferrous fumarate for paste)	17	18	mg

III. Processing Protocols

A. Bar Variables (A-28 and A-29)

1. Precooking and Grinding of Cereal Portion

a. Mix all dry ingredients thoroughly using a ribbon blender or equivalent for dry blending. Premix the oil and lecithin together and add slowly to dry ingredients while mixing. The oil and lecithin mix may be metered into the extruder during processing. Metered levels must be monitored at regular intervals to insure the delivery of the required levels.

b. Cook mixture using High Temperature Short Time Cooking (HTST) extruder. A Wenger TX52 twin screw extruder was used to produce prototypes.
   - Use 4-6mm circular die holes
   - Extruder screw configuration, jacket temperatures, yield, production rates, etc., should be established to insure a complete cook of the starch (Maltese Cross Test may be employed to validate starch cook) without any product scorching or burning of exterior of the extrudate.
   - Maintain die extrusion temperature between 295ºF -315ºF.
   - The extruded pellets should be a medium to dark tan without any burnt odors or flavors.

c. Extrudate Drying Procedure: Use a fluid bed, forced hot air or other types of forced air dryers, to dry product to a moisture range of 4-7%. Avoid scorching: there should be no burnt odors or flavors.

d. Grind: Grind dried pellets to a nominal particle size:
   - Rough Screen Analysis on prototype product ground at Natick Soldier Center (NSC) using a standard gravity-fed Fitzpatrick Comminuting Mill with a #2 (1.65mm) screen:

US Standard Sieve #	% Through
20	98-100
40	60-65
60	40-45
200	0-3

<u>Note:</u> Avoid a fine grind; do not exceed the 60 and 200 sieve recommendation. Product that has too small of a particle size will not compress properly during manufacturing phase of the bar production.

e. Other types of precooking methods may be explored as long as the final product meets all the functional requirements as demonstrated by the prototype. (Swept surface heat exchange, etc.)

2. Mixing Procedure for Bar Production

a. Mixing procedure successfully used by Combat Feeding Directorate in developing benchtop EFP prototype bar products.
   - Weigh out all dry and liquid ingredients (keep dry separate from liquid).
   - Add all dry ingredients (ground cereal mix, cream powder, sucrose, maltodextrin, vitamin/mineral premix) into a surface-sweeping High Shear (HS) Mixer (RoboCoupe Blixer BX6V with serrated S-type blade was used for prototype development) and blend on low speed (1,000-1,200 rpm) for 1 minute or until product is completely uniform.
   - In a separate container (steam-jacketed kettle or equivalent) heat: oils, rice syrup, lecithin, BHA, tocopherols to 140°F and mix until uniform.
   - Slowly add oil dispersion to HS Mixer while mixing at a low speed.

- Mix for 3-5 minutes on medium speed (~1,500 rpm) until mix appears to be homogeneous (no clumping, uniform color).

b. Alternative mixing procedures may be employed; however high-shear mixing is recommended and was the methodology used in the development of the aforementioned prototypes. Other types of mixing such as with a Hobart Mixer using an appropriate paddle and mixing procedure may be explored.
   - The final mix shall be homogeneous such that a stable bar can be made without visible dark "spots" appearing ("spots" are an indication of inadequate/non-homogeneous mixing).
   - When testing other mixing procedures, use the above mixing procedure as a control.

3. Bar Compression and Production

a. Compress mixed product into bars of nominal dimensions: length 2½", width 1¾" and thickness 0.58"-0.63". The thickness will vary slightly due to product mass, compression force (~ 2,000-2,200 lbs. of force was used in prototype development) and compression dwell time. Bars were successfully run in production quantities on a Stokes Compacting Single-Stage press.

b. Bars shall be compressed using enough force to hold the bar together for packaging purposes; however, excessive compression force will affect functional properties of the bar. Bars must retain dual purpose functionality, post production. They must be cohesive enough to handle and consume in the bar form as well as retain the ability to be crumbled up by hand and easily made into a porridge with the addition of tepid water.

4. Qualitative Assessment of Bar Functionality

a. Bar Cohesiveness: Bars shall be whole, intact and able to be handled without unintentionally crumbling or breaking.

b. Porridge procedure: Bars shall be able to be crumbled uniformly, using ones' fingers, into a container and with the addition of 110 grams of tepid water mixed for 1-3 minutes with a spoon or equivalent utensil. After a maximum of three minutes, the porridge should be uniform without hard lumps (oatmeal-like consistency).

B. Paste Variable (A-20)

1. Mixing Procedure

a. High-shear mixing protocol shall be used in order to obtain the proper viscosity of the product.

b. Weigh out all dry (sugar, cream powder, maltodextrin, NFDM, ascorbyl palmitate, salt, protein powders, vitamin/mineral premix, color) and liquid ingredients (oil, lecithin, BHA, tocopherols). Ensure that all dry ingredients are kept separate from liquid ingredients.

c. Add all dry ingredients into a surface-sweeping High Shear (HS) Mixer (RoboCoupe Blixer BX6V affixed with serrated S-type blade was used for prototype development) and blend on low speed (1,000-1,200 rpm) for 1 minute or until product is completely uniform.

d. In a separate container, mix oil, lecithin, tocopherols and BHA until uniform.

e. Slowly add oil dispersion to HS Mixer at low speed.

f. Mix for 5-10 minutes on medium speed until product takes on a "paste-like" (like soft peanut butter) consistency. Internal temperature of product should be 120°F to 140°F (max), after mixing is complete.

2. Fill Procedure

a. Fill pouches to 50g minimum (see pouch specifications below).

b. Pouches shall be either nitrogen-flushed or vacuum-packed so that residual oxygen content in the headspace of the sealed and filled pouches does not exceed 0.30 percent after 48 hours from time of sealing.

C. Nutrient Requirements

The Nutrients were based on the IOM report although there were some slight modifications in the premix when the prototypes were actually developed.

	Unit	IOM Requirements
Calories	**Kcal**	**2100**
A_w		**<0.60**
Moisture (vacuum)	**%**	**N/A**
Protein (Nitrogen Kjeldahl)	**Grams**	**53-74**
Nitrogen		
Crude Fat	**Grams**	**82-108**
Peroxide	**MEQ/KG**	**N/A**
Crude Fiber	**Grams**	**N/A**
Ash	**Grams**	**N/A**
Carbohydrate by difference	**Grams**	**210-263**
Iron	**mg**	**20-25**
Sodium	**Grams**	**2.1**
Potassium	**Grams**	**2.7**
Soluble Chloride	**Grams**	**3.2**
Zinc	**mg**	**22-24**
Thiamin	**mg**	**2.5-3**
Ascorbic Acid- Encapsulated)	**mg**	**210-420**
Vitamin A - true retinol	**ug**	**1050-2100**
Linoleic:Linolenic Ratio	**Ratio**	**5-10:1**
Lactose	**Grams/2100 Kcal**	**<36**

1. United States Department of Agriculture (USDA) in conjunction with USAID will identify critical macro/micronutrients for quality control monitoring and will establish sampling standards and methods to insure EFP's nutritional quality.

D. Final Product Description

1. A-28 Rice Bar: Compressed bar. The texture is to be firm enough to easily be unwrapped by the consumer without breaking into pieces but soft enough to be bitten into and chewed. The texture should be soft enough to be easily crumbled by hand into a container so that it can be mixed with water to form porridge. Odor will be of a grain (rice) with no scorched dairy notes. Appearance of bar shall be a uniform, medium to dark tan color with the absence of dark spots (which are an indication of inadequate mixing).

2. A-29 Wheat Bar: Same as A-28 but slightly darker in color. The odor will be more of a grainy wheat odor.

3. A-20 Paste: Creamy smooth texture comparable to a stiff peanut butter. Color should be a light tan peanut butter-like color. The product should be homogeneous with no noticeable color variations. The odor will be slightly bland with mild powdered milk notes.

IV. PACKAGING SPECIFICATIONS FOR USAID EFP PRODUCTS: PASTE (A-20), RICE-BASED BAR (A-28) AND WHEAT-BASED BAR (A-29)

A. Paste (A-20):

1. **Primary Packaging for Pastes**:
   Fifty grams of paste product shall be filled in a pouch formed by heat-sealing. Pouches shall be either nitrogen-flushed or vacuum-packed so that residual oxygen content in the headspace of the sealed and filled pouches does not exceed 0.30 percent after 48 hours from time of sealing. Inside dimensions of the pouch shall be 2 inches in width by 6 inches in length. The pouch material shall be fabricated from a 3-ply laminate consisting from inside to outside of minimum 0.002-inch thick polyolefin, extrusion-coated or laminated to 0.00035-inch thick aluminum foil, laminated to 0.0005-inch thick polyester. The three plies shall be laminated so that the aluminum foil is between the other two layers. The pouch color shall be white. The polyolefin layer of pouch material shall be suitably formulated for hot filling or post-fill processing, as applicable. The pouch shall be provided with V-shaped tear notches to facilitate easy opening of the pouch. Closure shall be accomplished with a 3/8 ± 1/8-inch wide heat seal. The closure seal shall be free of entrapped matter (for example, product residue) that reduces the effective closure seal to less than 1/16 inch wide. Not less than 24 hours after filling and sealing, the pouches shall withstand an internal pressure of 17 per square inch gauge (psig) for 30 seconds without rupture or seal separation greater than 1/16 inch or seal separation that reduces the effective closure seal width to less than 1/16 inch. The filled and sealed pouch shall not leak or show evidence of delamination. The pouch shall show no fold-over wrinkles or aberrations in the pouch material or heat seals. Filled and sealed pouches showing fold-over wrinkles or aberrations shall withstand a minimum internal pressure of 17 psig to verify package integrity. The pouch material shall not transfer any foreign flavor or odor to the product being packaged.

   - Labeling of Primary package – *See Appendix 1: Appendix 1: A-20 Primary*

2. **Secondary Packaging for Pastes:**
   White click-lock paperboard carton constructed of 26 point (or equivalent) paperboard (see attachment). Inside dimensions shall be nominally 7 inches in length by 5 inches in width by 2-1/4 inches in depth. The caliper of the paperboard shall be sufficient to need to refine dimensions for 9 pouch package.

   - Labeling of Secondary Package – *See Appendix 2: A-20 Secondary*

3. **Tertiary Packaging:**
   Based on above dimensions of secondary package shipping, container size will be dependent upon final size of secondary package to be able to determine dimensions for efficient pallet pattern, not to exceed 40 lbs. per case.

   a. **Tertiary Packaging (shipping carton) labeling:**
      See attached PDF file for wording and logo. Boxes may be preprinted, or printed on line, or a preprinted label affixed to carton. Edit PDF file as to title, units/carton, and weight appropriate to specific product.

      See Appendix 3: A-20 Tertiary

B. Bars (A-28 and A-29)

1. **First Package for Bars:**
   Each 55-gram bar shall be placed into a polyolefin shrink film and shrink-wrapped, thin monolayer (customer has preference for polypropylene) wrap to provide low-level protection to bars.

2. **Primary Package for Bars:**
   Nine shrink-wrapped bars (3 by 3), are placed into a brick-style foil package. Inside dimensions are to be nominally 6-3/4 inches in width by 9 inches in length and heat-sealed under vacuum (see below).

   a. Pouch material: The pouches shall be fabricated from 0.0035-inch thick linear low-density polyethylene sealant layer laminated or extrusion-coated to 0.00035-inch thick aluminum foil, which is then bonded with 10 pound per ream low-density polyethylene to 0.0006-inch thick biaxially oriented nylon. The three plies shall be laminated with the nylon on the exterior of the pouch. Alternatively, pouches may be fabricated from 0.0035-inch thick linear low density polyethylene sealant layer laminated or extrusion-coated to 0.0006-inch thick biaxially oriented nylon, which is laminated to 0.00035-inch thick aluminum foil, which is bonded to 0.0005-inch thick polyester. The linear low-density polyethylene sealant film shall be heat-sealable and capable of producing a fusion seal or shall be heat-sealable and peelable. All tolerances for thickness of pouch materials shall be plus or minus 20 percent. The pouch shall be colored white. The material shall show no evidence of delamination, degradation or foreign odor when heat-sealed or fabricated into pouches. The material shall be suitably formulated for food packaging and shall not impart an odor or flavor to the product.

   b. Pouch construction. The pouch shall be a prefabricated, square-bottom, gusset-style bag having inside dimensions of 3-3/8 inches (± 1/8 inch) for the face width, 2-9/16 inches (± 1/8 inch) for the gusset width, and 10 inches (± 1/8 inch) in length. The pouch shall be fabricated by heat-sealing a fin seal down the length of the pouch and a bottom seal along the face of the pouch. Heat seals shall have a minimum width of ¼ inch. The heat seal shall have an average seal strength of not less than 7 pounds per linear inch and no individual specimen shall have a seal strength of less than 6 pounds per linear inch when seal strength tested in accordance with ASTM F88. Heat-sealed pouches shall be provided with appropriate tear nicks, notches or serrations to facilitate easy opening of the pouch. Alternatively, a flat-style pouch having inside dimensions not greater than 6-3/4 inches in width by 9 inches in length may be used in lieu of a gusseted pouch.

   c. Pouch filling and sealing. Nine bars, 3 by 3 stack (see options above) of product shall be filled into the pouch. The filled pouches shall be sealed under a vacuum level of 23 inches of mercury. The sealed pouches shall show no evidence of material degradation or delamination. The closure seal shall be free of fold-over wrinkles or entrapped matter that reduces the effective closure seal to less than 1/16 inch. Seals shall be free of impression or design on the seal surface that would conceal or impair visual detection of seal defects. The heat seal shall have an average seal strength of not less than 7 pounds per linear inch and no individual specimen shall have a seal strength of less than 6 pounds per linear inch when tested in accordance with ASTM F88. The filled pouch shall have a minimum 1/8-inch width heat seal.

   d. Pouch Labeling. Each pouch shall be clearly printed or stamped in a manner that does not damage the pouch, with a food-compatible, permanent black ink, or other dark, contrasting color, which is free of carcinogenic elements or ingredients. The information shall be located on the body of the pouch opposite the fin seal, and not closer than 1/16 inch to any seal. If a non-contact type printer is used, the information may be located

anywhere on the pouch (in one complete print), except the fin seal face and the closure seal area. The label shall contain the following information:

See Appendix 4: A-28 Primary
See Appendix 5: A-29 Primary

and

3. Secondary package for bars:
One brick (containing 9 bars, 3x3 configuration, vacuum-sealed) to be inserted into a white, paperboard carton and closed or sealed, inside dimensions of carton: nominally 5.25 inches in length, by 2.5 inches in width, by 1.875 inches in height.

- Labeling of secondary package on following attachments:

See Appendix 6: A-28 Secondary
See Appendix 7: A-29 Secondary

and

- Bulk pack the 9 bar bricks into shipping cartons: carton not to exceed 40 lbs.

4. **Tertiary package for bars:**
Labeling of shipping carton: See below the attached PDF file for logo and label wording. Boxes may be preprinted, printed online, or a preprinted label affixed to carton. Edit PDF file as to title, units/carton, and weight appropriate to product.

See Appendix 8: A-28 Tertiary
See Appendix 9: A-29 Tertiary

and

C. QUALITY ASSURANCE PROVISIONS APPLICABLE TO PASTE TUBES/POUCHES.

1. **Filled and sealed pouch examination.** The filled and sealed pouches shall be examined for the defects listed in Table I. The lot size shall be expressed in pouches. The sample unit shall be one filled and sealed pouch. The inspection level shall be I and the acceptable quality level (AQL), expressed in terms of defects per hundred units, shall be 1.5 for major defects and 4.0 for minor defects. A minimum of 200 samples shall be examined for critical defects. The finding of any critical defect shall be cause for rejection of the lot.

TABLE I. Filled and sealed pouch defects [1]

Category			Defect
Critical	**Major**	**Minor**	
1			Tear, hole, or open seal.
2			Swollen pouch.
3			Aberrations in pouch material or heat seals resulting from heat-sealing, pouch fabrication, hot filling or heat processing that reduce the effective closure seal width to less than 1/16 inch. [2/]
	101		Seal widths not as specified.
	102		Not heat-sealed as specified.
	103		Inside pouch dimensions not as specified.
	104		Closure seal not located as specified.
	105		Closure or top seal extends into or below tear notch location.
	106		Not clean. [3/]
	107		Required labeling or marking missing, incorrect, illegible or smudges.
	108		Embossed code marking not located as specified.
	109		Distance between inside edge of tear notch or serrations and inside edge of seal is less than 3/16 inch.
	110		Presence of entrapped matter (for example, product residue) that reduces the effective closure seal to less than 1/16-inch wide. [4/]
		201	Tear notch or serrations missing.
		202	Tear notch or serrations not located as specified.
		203	Depth of tear notch or serrations not as specified.
		204	Excess pouch material at edges exceeds 3/16 inch.

[1/] Any evidence of insect or rodent infestation shall be cause for rejection of the lot.

[2/] Aberrations in pouch material or heat seals include:

a. Major fold-over wrinkles or severe wrinkles, that extend into heat seal area and reduce effective seal width to less than 1/16 inch; or

b. Severe wrinkles in the body of the pouch along the inside edges of the heat seals.

Pouches exhibiting one or more of these aberrations shall be tested in accordance with 4.5.7.

[3/] Outer packaging shall be free from foreign matter, which is unwholesome, has the potential to cause pouch damage (for example, glass, metal fillings, etc.) or generally detracts from the clean appearance of the pouch. The following examples shall not be scored as defects for unclean:

a. Foreign matter which presents no health hazard or potential pouch damage and which can be readily removed by gently shaking the pouch or by gently brushing the pouch with a clean dry cloth.

b. Dried product, which affects less than 1/8 of the total surface area of one pouch face (localized and aggregate).

c. Water spots.

d. Very thin film of grease, oil, or product residue which is discernible to touch but is not readily discernible by visual examination.

[4/] The effective closure seal is defined as any uncontaminated, fusion-bonded, continuous path, minimum 1/16-inch wide from side seal to side seal that produces a hermetically sealed pouch.

2. **Pouch leakage and delamination examination.** All exterior surfaces and edges of the filled and sealed pouch shall be examined visually for product leakage while applying a manual kneading action which forces the product against the interior pouch surface in the area being observed. After leakage testing, the pouch shall be examined for evidence of delamination. Any product leakage from the pouch or evidence of delamination of the pouch shall be classified as a major defect, except delamination of outer ply when located in the seal area 1/16 inch or further from the food product edge of seal. Pouches exhibiting this type of delamination shall be tested by manually flexing the delaminated area 10 times. The area of delamination shall be held between the thumb and forefinger of each hand with both thumbs and forefingers touching each other. The delamination area shall then be rapidly flexed by rotating both hands in alternating clockwise/counterclockwise directions. Care shall be exercised when flexing delaminated area near the tear notches to avoid tearing the pouch material. After flexing, the separated outer ply shall be grasped between the thumb and forefinger and gently lifted toward the food product edge of the seal. If the separated area is too small to be held between thumb and forefinger, a number two stylus shall be inserted into the delaminated area and a gentle lifting force applied against the outer ply. If separation of the outer ply can be made to extend to less than 1/16 inch from the product edge of the seal with no discernible resistance to the gentle lifting, the pouch shall be rejected. The lot size shall be expressed in pouches. The sample unit shall be one filled and sealed pouch. The inspection level shall be I and the AQL, expressed in terms of defects per hundred units, shall be 0.65.

3. **Internal pressure test.** Internal pressure resistance shall be determined by pressurizing the pouches while they are restrained between two rigid plates spaced 1/2 $\pm$ 1/16 inch apart. If a three-seal tester (one that pressurizes the pouch through an open end) is used, the closure seal shall be cut off for testing the side and bottom seals of the pouch; for testing of the closure seal, the bottom seal shall be cut off. The pouches shall be emptied and cleaned thoroughly with a mild detergent and water solution prior to testing. If a four-seal tester (designed to pressurize filled pouches by use of a hypodermic needle through the pouch wall) is used, all four seals can be tested simultaneously. Pressure shall be applied at an approximate uniform rate of 1 pound psig per second until 17 psig pressure is reached. The 17 psig pressure shall be held constant for 30 seconds and then released. The pouches shall then be examined for separation of yield of heat seals. Any rupture of evidence of seal separation that reduces the effective closure seal width to less than 1/16 inch (see 5.1.1) shall be considered a test failure. The lot size shall be expressed in pouches. The sample unit shall be one filled and sealed pouch. The inspection level shall be S-1. Any test specimen failing to meet the internal pressure requirements specified in 5.1.1 shall be classified as a major defect and shall be cause for rejection of the lot.

D. QUALITY ASSURANCE PROVISIONS APPLICABLE TO BRICK PACK POUCHES

1. **Filled and sealed pouch examination.** The filled and sealed pouches shall be examined for the defects listed in Table I. The lot size shall be expressed in pouches. The sample

unit shall be one pouch. The inspection level shall be general inspection level I and the acceptable quality level (AQL), expressed in terms of defects per hundred units, shall be 0.65 for major defects and 4.0 for minor defects.

TABLE II. Filled and sealed pouch defects [1/]

Category	Defect		
Critical	**Major**	**Minor**	
1			Tear, hole, or open seal.
	102		Seal width less than 1/16 inch.[2/]
`	103		Presence of delamination.[3/]
	104		Unclean pouch.[4/]
	105		Pouch has foreign odor.
	106		Any impression or design on the heat seal surfaces which conceals or impairs visual detection of seal defects.[5/]
	107		Any evidence of loss of vacuum. [6/]
	108		Peelable pouch does not open where indicated.
	201		Label smudges, is missing, incorrect, or illegible.
	202		Tear nick, notch or serrations missing or does not facilitate easy opening (applicable to fusion-sealed pouches only).
	203		Seal width less than 1/8 inch but greater than 1/16 inch.
	204		Presence of delamination. [3/]

[1/] Any evidence of rodent or insect infestation shall be cause for rejection of the lot.

[2/] The effective closure seal is defined as any uncontaminated, fusion-bonded, continuous path, minimum 1/16-inch wide, from side seal to side seal that produces a hermetically sealed pouch.

[3/] Delamination defect classification:

a. Major Defects:

1). Delamination of the outer ply in the pouch seal area that can be propagated to expose aluminum foil at the food product edge of the pouch after manual flexing of the delaminated area. To flex, the delaminated area shall be held between the thumb and forefinger of each hand with both thumbs and forefingers touching each other. The delaminated area shall then be rapidly flexed 10 times by rotating both hands in alternating clockwise-counterclockwise directions. Care shall be exercised when flexing delaminated areas near the tear notches to avoid tearing the pouch material. After flexing, the separated outer ply shall be grasped between thumb and forefinger and gently lifted toward the food product edge of the seal or if the separated area is too small to be held between thumb and forefinger, a number two stylus shall be inserted into the delaminated area and a gentle lifting force applied against the outer ply. If separation of the outer ply can be made to extend to the product edge of the seal with no discernible resistance to the gentle lifting, the delamination shall be classified as a major defect. Additionally, spot delamination of the outer ply in the body of

the pouch that is able to be propagated beyond its initial borders is also a major defect. To determine if the laminated area is a defect, use the following procedure: Mark the outside edges of the delaminated area using a bold permanent marking pen. Open the pouch and remove the contents. Cut the pouch transversely not closer than 1/4 inch (± 1/16 inch) from the delaminated area. The pouch shall be flexed in the area in question using the procedure described above. Any propagation of the delaminated area, as evidenced by the delaminated area exceeding the limits of the outlined borders, shall be classified as a major defect.

b. Minor Defects:

1). Minor delamination of the outer ply in the pouch seal area is acceptable and shall not be classified as a minor defect unless it extends to within 1/16 inch of the food product edge of the seal. All other minor outer ply delamination in the pouch seal area or isolated spots of delamination in the body of the pouch that do not propagate when flexed as described above shall be classified as minor defects.

[4/] Outer packaging shall be free from foreign matter that is unwholesome, has the potential to cause pouch damage (for example, glass or metal filings) or generally detracts from the clean appearance of the pouch. The following examples shall not be classified as defects for unclean:

a. Foreign matter that presents no health hazard or potential pouch damage and which can be readily removed by gently shaking the package or by gently brushing the pouch with a clean dry cloth.

b. Dried product that affects less than 1/8 of the total surface area of one pouch face (localized and aggregate).

c. Water spots.

[5/] If doubt exists as to whether or not the sealing equipment leaves an impression or design on the closure seal surface that could conceal or impair visual detection of seal defects, samples shall be furnished to the contracting officer for a determination as to acceptability.

[6/] The filled and vacuum-sealed pouches shall be visually examined for conformance to the vacuum requirement in Section IV B. 2. c not less than 96 hours after filling and sealing. The sealed pouch shall continue to exhibit tight adherence to the surface contours of the contents when a pulling force is applied at the top and bottom seal. This force shall be applied by holding the top and bottom seal between the thumb and forefinger of each hand, while simultaneously exerting a slight pull with both hands. Any evidence of loss of vacuum shall be classified a major defect.

2. Seal testing. The pouch seals shall be tested for seal strength as required in **a.** or **b.** below.

a. Unfilled preformed pouch seal testing. The seals of the unfilled preformed pouch shall be tested for seal strength in accordance with ASTM F 88, Seal Strength of Flexible Barrier Materials. The lot size shall be expressed in pouches. The sample size shall be the number of pouches indicated by inspection level S-1. Three adjacent specimens shall be cut from the sealed side or end of each pouch in the sample. The average seal strength shall be calculated by averaging the three specimens cut from that side or end. When testing the end seal of the pouch, one of the three specimens shall be cut from the center of the seal incorporating the folded fin seal juncture of the heat seal. For heat seals, any average seal strength of less than 7 pounds per linear inch or any test specimen with a seal strength of less than 6 pounds per linear inch shall be cause for rejection of the lot.

b. Pouch closure seal testing. The closure seals of the pouches shall be tested for seal strength in accordance with ASTM F 88, Seal Strength of Flexible Barrier Materials. The lot size shall be expressed in pouches. The sample size shall be the number of pouches indicated by inspection level S-1. For the closure seal on preformed bags, three adjacent specimens shall be cut from the closure seal of each pouch in the sample. One of the specimens shall be cut from the center of the seal incorporating the folded fin seal juncture of the heat seal. The average seal strength of any side, end or closure shall be calculated by averaging the three specimens cut from that side, end or closure. For fusion heat seals, any average seal strength of less than 7 pounds per linear inch or any

test specimen with a seal strength of less than 6 pounds per linear inch shall be cause for rejection of the lot.

3. Packing.

a. Shipping container examination. The filled and sealed shipping containers shall be examined for the defects listed below. The lot size shall be expressed in shipping containers. The sample unit shall be one shipping container fully packed. The inspection level shall be S-3 and the AQL, expressed in terms of defects per hundred units, shall be 4.0 for major defects and 10.0 for total defects.

- Major: National stock number, item description, contract number, name and address of producer, or date of pack missing, incorrect or illegible
  Container not properly closed
  Components missing, damaged, or not as specified

- Minor: Other required markings missing, incorrect, or illegible
  More than 35 pounds of product

E. PACKAGING REQUIREMENTS AND QUALITY ASSURANCE PROVISIONS FOR DEHYDRATED PRODUCT IN A BRICK PACK POUCH

SECTION J REFERENCE DOCUMENTS

DPSC FORM

DPSC FORM 3556 Marking Instructions for Shipping Cases, Sacks and Palletized/Containerized Loads of Perishable and Semiperishable Subsistence, May 96

FEDERAL SPECIFICATION

L-P-378 – Plastic Sheet and Strip, Thin Gauge, Polyolefin

FEDERAL STANDARD

FED-STD-595 – Colors Used in Government Procurement

NON-GOVERNMENTAL STANDARDS

AMERICAN SOCIETY FOR QUALITY CONTROL (ASQC)

ANSI/ASQCZ1.4-1993 – Sampling Procedures and Tables for Inspection by Attributes

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

F 88 – Seal Strength of Flexible Barrier Materials

ATTACHMENT I
RESULTS OF SIX MONTHS @ 100ºF AND 24 MONTHS @ 80ºF SHELF-LIFE STUDIES WITH VITAMIN AND MINERAL PREMIX RECOMMENDATIONS

I. Methods:

Samples of each product were stored at controlled temperature of 100ºF, for 6 months, and 80ºF for 24 months. Samples were also stored at 0ºF to serve as controls. For the 100ºF test, pulls were taken at 2, 4 and 6 months. For the 80ºF test, pulls were taken at 6, 12, 18, and 24 months. After each pull, samples were sent to Eurofins (3507 Delaware Ave., Des Moines, IA 50313) Analytical Laboratory for determination of vitamin A, vitamin C and vitamin B1. These vitamins were chosen because they are the most labile vitamins, and they are frequently scrutinized due to their unstable nature. Peroxide value (indicator of oxidative rancidity) was measured only for the paste. The bars were vacuum-packed in moisture- and oxygen-barrier laminated foil, so it was not necessary to determine peroxide value. The remaining product from each pull was stored at 0ºF for organoleptic analysis, conducted at the completion of the test.

II. Results:

A. Summary of the six-month, 100ºF nutrient stability tests:

1. **Oxidation Results**: The peroxide value (a measure of oxidative rancidity) was measured for the A-20 paste variable for the duration of the test and remained < 0.2 mg/lb. This indicates that the lipids did not become rancid and that the nitrogen-flush procedure used to fill the pouches was sufficient to prevent oxidative rancidity.

2. **Vitamin A Stability Results:** The most unstable micronutrient in the A-20 paste variable was vitamin A, which showed a 45% loss over 6 months @100ºF storage. However, vitamin A levels (770µg) were only 27% less than the target Minimum Daily Levels per Daily Ration (MRL/DR) of 1050µg (see Table I). See graph on Figure 4 for vitamin A loss trend and Table I for MRL/DR. The slope would indicate that this negative trend will continue, but the rate of degradation will be mitigated over time.

   However, the vitamin A held up well in bars, with sufficient levels remaining after six months at 100ºF (see graphs on Figures 1-3 for trends and Table I for data), which meets or exceeds the MDL's for this nutrient. A likely explanation for the difference in vitamin A stability between the two types of products is the significantly higher molecular mobility in the paste as opposed to the bars. Also, since the vitamin A is encapsulated in a hardened oil coating, and the continuous phase is non-polar, the encapsulate may dissolve in the mobile lipid phase. Another practical explanation is that the encapsulation is possibly compromised during production since high shear mixing is used to form the paste dispersion.

3. **Vitamin C Stability Results:** Vitamin C also incurred significant losses, in the bar products. Vitamin C fell below the MRL/DR to an average of 76 mg in the bars and 10 mg in the paste (A-20). Average percent losses for the bars and the paste were 35% and 5%, respectively (see Table I). Graphical depiction of the loss trends are shown in Figures 1-3.

   Since vitamin C is a labile vitamin, increasing initial fortification levels to compensate for anticipated losses may be necessary to ensure MRL/DR levels are met throughout the shelf life of this product.

4. **Vitamin B_1 (Thiamine) Stability Results:** Accelerated storage had little effect on thiamine levels in the bars. Sufficient vitamin B_1 remained in both variables to meet the MRL/DR.

   The paste, however, variable did incur a greater loss of thiamine, which dropped to 0.6 mg below the required minimums (approximately 24% loss over time). The loss trend indicates that thiamine may continue to degrade over time. However, vitamin losses may be compensated for through increased fortification of the vitamin-mineral premix.

B. Summary of the 24-month, 80ºF nutrient stability test:

1. **Vitamin A Stability Results:** Vitamin A results in the 24-month study were consistent with those from the accelerated study in that the paste variable again suffered losses resulting in levels below the MRL, this time by up to 22.5% (see Table II for data and Tables V-VIII for trends).

   The bar variables (A-28 and A-29) maintained fortified levels and easily met or exceeded minimum requirements for the daily ration.

2. **Vitamin C Stability Results:** Vitamin C in the EFPs fell below the MRL/DR by an average of 16 mg, or 7.6%, in the bars, while the paste maintained levels above the minimum daily requirements

3. **Vitamin B_1 (Thiamine) Stability Results:** There were no significant losses in thiamine over the 24 month study for either bar variables or the paste variable. All prototypes retained MRL's for all EFP variables.

C. Basis for Vitamin-Mineral Premix Recommendations:

While 6 months of storage at 100ºF produced the greater overall losses, both tests indicated the same trends. According to existing US Army specifications regarding shelf-life testing, 100ºF accelerated storage test is equivalent to 3 years at 80ºF. Since the 100ºF test was the more severe evaluation and yielded greater losses in vitamin levels, all recommendations for increasing premix levels will be made based on the six-month 100ºF accelerated storage test.

D. Summary of Vitamin-Mineral Premix Changes

It is recommended that the vitamin and mineral premixes should be adjusted to the specific needs of each type of EFP variable. The bar and paste variables should each have its own premix formulation to ensure compliance with its specific nutrient requirements. The vitamin stability study showed that, due to inherent differences in the product matrices, nutrient losses during extended storage were not the same for the paste and bar variables.

Micronutrient changes in the vitamin-mineral premix are addressed in Tables III and IV. Increased concentrations of specific labile vitamins (A, C, B_1) in the premix should enable the EFPs to retain MRLs over a storage period of two years at 70ºF.

USAID determined that zinc and iron were the most important minerals (nutritionally) for the target populations. Since minerals are inherently very stable, only these two were analyzed in the products for content (see Table Va). Both minerals yielded lower than anticipated levels which were probably due to insufficient amounts in the ingredients themselves. The micronutrient analysis was determined by the combination of minerals added for fortification (from the premix) and those inherently existing in the ingredients that make up the EFP. Since the nutrient makeup of ingredients can vary significantly (based on harvesting times, for example) it was determined that the most essential minerals (iron and zinc) should be fortified to levels just below the MRL to ensure appropriate levels are maintained. Demonstrated losses during extended storage and the inherent variability of ingredients are accounted for in the premix formulas, which are documented in Tables III and IV.

E. Summary of Product Macronutrient Analysis

The original macronutrient requirements for the EFP were based on the previously mentioned IOM publication. Slight variations in the macronutrient composition were approved by USAID to ensure functional and/or nutritional guidelines of the EFP variables were attained.

The A-20 paste variable was required to be a semisolid dispersion, capable of being squeezed out of a foil pouch and readily consumed. The paste was initially formulated to IOM standards, but was not a functionally acceptable product (dry, crumbly, lacked appropriate flow properties). At that point in time Natick technologists requested that the ceiling on the fat content be lifted to assist in developing a texturally acceptable product. USAID representatives approved the proposed modifications in nutritional content to facilitate the development of the paste variables with appropriate functional and organoleptic properties.

The A-28 and A-29 bar variables were initially under the MRL for protein content. Natick technologists recommended and USAID accepted an increase in daily ration serving size to compensate for nutrient shortcomings. Daily ration was increased from 450 g/day to 500 g/day to achieve macronutrient goals. The only issue was that the carbohydrate levels slightly exceeded IOM limits. However, it was determined by USAID that the excess carbohydrates was a non-issue.

F. Summary of Textural Analysis of Bars:
Breaking strength (hardness) of A-28, A-29 over six months @100ºF.

The bars showed a definite increase in instrumental hardness/firmness throughout six months @ 100ºF storage (Figure 9). However, increase in breaking strength leveled off at six months, suggesting that firmness had reached an asymptotic and further textural hardening is unlikely.

The bars were also evaluated by Natick food technologists during sensory testing. It was determined that the stored products had hardened noticeably compared to time zero controls, and their ease of crumbling (in order to make porridge) had declined. However, while the bars did harden, it was determined that the six-month stored products were still texturally and functionally acceptable. They re-hydrated with tepid water in an acceptable time, and the initial bite and overall mouthfeel did not impede proper mastication.

G. Summary of Organoleptic Changes in EFPs during Accelerated and Ambient Storage Testing

Stored EFP products were paneled by Natick food technologists. Prior to paneling, they were given a synopsis (see Figure 9a) of the organoleptic guidelines and background information on the target populations to acclimate panelists to the desirable characteristics of the prototypes. Control specimens (stored at 0°F) were also evaluated to quantitatively determine the extent of degradation during storage.

Acceptance data generated from sensory panels are based on a hedonic range of 1-9 (see Figures 10a, 10b, and Table VI). The stored EFP prototypes were required to have a minimum hedonic score of 5. The bar prototypes, it should be noted, were evaluated in two forms: first, in its initial bar form; and then crumbled up and mixed with tepid water to form a porridge or gruel.

All stored products surpassed minimum acceptance scores and were deemed suitable for consumption (see Table VI). Panelists had higher preference scores for the paste forms of the product; however, differences were marginal.

Although all the stored products were acceptable, variables stored at 100ºF for 6 months showed evidence of storage degradation (i.e., browning, firming and development of off-flavors) versus the controls. However, product stored at long-term ambient storage (two years at 80ºF) prototypes held up very well and showed only slight decrements in overall quality (see Figures 11 and 12).

IV. Conclusion:

The Natick Soldier RDEC has successfully completed development, commercial producibility demonstration and shelf-life validation of all three prototypes (rice bar, wheat bar, and paste). These products meet all USAID contractual agreements (see Attachment III for the Scope of Work). The USAID product requirements were drafted based on the IOM report, "High-Energy, Nutrient-Dense Emergency Relief Food Product," with minor changes in the required macronutrient ratios and serving sizes in order to retain functional properties (i.e., retention of paste flow properties) and meet minimum macronutrient requirements (i.e., daily ration size of 500g to ensure adequate protein consumption).

All the prototypes were stressed (6 months at 100ºF and 24 months at 80ºF) under conditions surpassing the contractual storage requirements of 30 months @ 70ºF (see attached Reimbursement Agreement III; Scope of Work). The results of this report indicate that the products can be successfully stored for six months @ 100ºF, which is equivalent to three years at 80ºF. Natick-administered sensory evaluations of all stored EFPs, using trained panelists, yielded hedonic rating scores of 5 or higher, which surpasses mandated standards outlined in attachment 1; page 9 "Acceptability".

The products initially met all nutritional requirements outlined in the reimbursement agreement. However, analysis of stored items showed some of the more labile vitamins may require additional fortification, which is addressed in the recommended premix formulations (Tables III, IV). It should be noted that all analysis was performed by a third party, accredited analytical laboratory (Eurofins, Inc.). With the recommended minor adjustments in the vitamin and mineral premix (i.e., increasing amounts of highlighted nutrients), all nutritional goals will be met.

Commercial producibility was demonstrated through successful runs at a U.S. manufacturer (Datrex, Inc.). All products used for in-house evaluations and external field testing by USAID were produced commercially at the aforementioned manufacturer. The high acceptance of the bar and the paste products demonstrate the feasibility of their large-scale commercial production according to the contractual guidelines outlined in Attachment III.

Table I. Vitamin Levels after Six-Months at 100ºF compared to Minimum Required Levels (MRL)

Vitamin	Minimum Required Levels/Daily Ration	Actual Values after Six Months				Difference from MRL/DL
		A-28 500g	A-29 500g	A-28,29 Average	A-20 450g	Ave. A28,A29/A20 500g*/450g
C (mg)	210	135	133	134	200	-76 mg/-10 mg
B^1 (mg)	2.50	2.62	3.00	2.74	1.90	+.2 mg/-0.6 mg
A (µg)	1050	1160	1180	1170	770	+20 ug/-280 µg

Table II: Vitamin Levels after Two years at 80ºF compared to Required Minimum Levels (MRL)

Vitamin	Minimum Required Levels/Daily Ration	Actual Values after Two Years				Difference from MRL/DR
		A-28 500g	A-29 500g	A-28,29 Average	A-20 450g	500g*/450g
C (mg)	210	197	191	194	223	-16 mg/0 mg
B^1 (mg)	2.50	3.30	4.18	3.74	2.60	+1.2 mg/-0.1 mg
A (µg)	1050	1191	1242	1216	813	+25 µg/-237 µg

Table III: Vitamins and Minerals for A-28 and A-29

Required Vitamins and Minerals per 500 grams of product	Current Fortitec FT 032163	Recommended Formula Changes in Yellow	
Encapsulated Vitamin A (as Palmitate, USP-FCC)	3497.00	3497.00	IU
Vitamin D3 (as Cholecalciferol, USP-FCC)	400.00	400.00	IU
Vitamin E (as acetate, USP)	30.00	30.00	IU
Vitamin K1 (as Phytonadione, FCC)	0.10	0.10	mg
Encapsulated Vitamin C (as Ascorbic Acid, USP-FCC)	200.00	280.00*	mg
Encapsulated B1 (as Thiamin Mononitrate, USP-FCC)	1.70	1.70	mg
Vitamin B2 (as Riboflavin, USP-FCC)	1.80	1.80	mg
Niacin (as Niacinamide, USP-FCC)	12.00	12.00	mg
Vitamin B6 (as Pyridoxine HCl, USP-FCC)	2.00	2.00	mg
Folic Acid (USP-FCC)	0.40	0.40	mg
Vitamin B12 (as Cyanocobalamin, USP)	25.00	25.00	mcg
Biotin (FCC)	50.00	50.00	mcg
Pantothenic Acid (D-Calcium Pantothenate, USP)	7.00	7.00	mg
Calcium (as Tricalcium Phosphate, FCC)	600.00	600.00	mg
Phosphorus (as Dipotassium Phosphate, FCC & as Tricalcium Phosphate, FCC)	1000.00	1000.00	mg
Magnesium (as Magnesium Oxide, USP)	200.00	200.00	mg
Zinc (as Zinc Oxide, USP)	15.00	18.50**	mg
Copper (as Cupric Oxide)	0.90	0.90	mg
Manganese (as Manganese Sulfate, USP-FCC)	0.50	0.50	mg
Selenium (as Sodium Selenate)	40.00	40.00	mcg
Chromium (as Chromium Chloride (6 H2O), USP)	25.00	25.00	mcg
Iodine (as Potassium Iodide, USP-FCC)	0.10	0.10	mg
Iron (as Iron EDTA)	15.00	17.00**	mg
Potassium (as Dipotassium Phosphate, FCC)	1849.00	1849.00	mg

*** See Table I**
**** See Table V.a**

Table IV: Vitamins and minerals for A-20

Required Vitamins and Minerals per 450 grams of product	Current Fortitec FT 032163	Recommended Formula Changes in Yellow	
Encapsulated Vitamin A (as Palmitate, USP-FCC)	3497.00	3800.00*	IU
Vitamin D3 (as Cholecalciferol, USP-FCC)	400.00	400.00	IU
Vitamin E (as acetate, USP)	30.00	30.00	IU
Vitamin K1 (as Phytonadione, FCC)	0.10	0.10	mg
Encapsulated Vitamin C (as Ascorbic Acid, USP-FCC)	200.00	220.00*	mg
Encapsulated B1 (as Thiamin Mononitrate, USP-FCC)	1.70	1.80*	mg
Vitamin B2 (as Riboflavin, USP-FCC)	1.80	1.80	mg
Niacin (as Niacinamide, USP-FCC)	12.00	12.00	mg
Vitamin B6 (as Pyridoxine HCl, USP-FCC)	2.00	2.00	mg
Folic Acid (USP-FCC)	0.40	0.40	mg
Vitamin B12 (as Cyanocobalamin, USP)	25.00	25.00	mcg
Biotin (FCC)	50.00	50.00	mcg
Pantothenic Acid (D-Calcium Pantothenate, USP)	7.00	7.00	mg
Calcium (as Tricalcium Phosphate, FCC)	600.00	600.00	mg
Phosphorus (as Dipotassium Phosphate, FCC & as Tricalcium Phosphate, FCC)	1000.00	1000.00	mg
Magnesium (as Magnesium Oxide, USP)	200.00	200.00	mg
Zinc (as Zinc Oxide, USP)	15.00	22.00**	mg
Copper (as Cupric Oxide)	0.90	0.90	mg
Manganese (as Manganese Sulfate, USP-FCC)	0.50	0.50	mg
Selenium (as Sodium Selenate)	40.00	40.00	mcg
Chromium (as Chromium Chloride (6 H2O), USP)	25.00	25.00	mcg
Iodine (as Potassium Iodide, USP-FCC)	0.10	0.10	mg
Iron (as Chelated Iron)	15.00	18.00**	mg
Potassium (as Dipotassium Phosphate, FCC)	1849.00	1849.00	mg

*** See Table I.**
**** See Table V.a**

Table V.a: Analytical Analysis. A-28 & A-29 data from combined samples drawn from every batch. A-20 data from combined samples from 8 points in time during the production.

Assay	Unit	IOM Requirements	A28	A29	Paste A20
Calories	Kcal	2100	2234	2286	2425
Aw		<0.60	0.356	0.358	0.310
Moisture (vacuum)	%	N/A	4.58	4.48	2.23
Protein (Nitrogen Kjeldahl)	Grams	53-74	62.50	69.70	50.45
Nitrogen			2.00	2.23	1.79
Crude Fat (Soxlet Extraction)	Grams	82-108	80.45	84.05	*
Crude Fat (Acid Hydrolysis)	Grams	82-108	86.50	95.50	137.61
Peroxide	MEQ/KG	N/A	N/A	N/A	<2.0
Crude Fiber	Grams	N/A	3.50	5.00	
Dietary Fiber					1.35
Ash	Grams	N/A	18.60	18.85	16.90
Carbohydrate by Difference	Grams	210-263	302	287	229
Iron	mg	20-25	19.50	21.50	18.00
Sodium	Grams	2.1	2.40	2.40	2.66
Potassium	Grams	2.7	3.80	3.95	3.85
Soluble Chloride	Grams	3.2	3.75	3.75	3.29
Zinc	mg	22-24	19.50	19.00	15.75
Thiamin	mg	2.5-3	2.27	3.66	3.62
Ascorbic Acid-Encapsulated	mg	210-420	222	222	200
Vitamin A - True Retinol	ug	1050-2100	1357	1668	752*
Linoleic:Linolenic Ratio	Ratio	5-10:1	9.1:1	8.7:1	8.4:1
Lactose	Grams/2100 Kcal	<36	<10.5	<10.5	<10.5
SUGARS					
Fructose	%		<.2	<.2	<.2
Glucose	%		0.23	<.2	0.31
Lactose	%		<.5	<.5	<.5
Maltose	%		1.25	0.99	5.63
Sucrose	%		9.77	6.73	17.40

*** soxlet fat analysis not recommended for the paste**

Table V.b: Fatty acid profile

Assay	A28 (Rice Bar)	A29 (Wheat Bar)	A-20 (Paste)		A28-2 (Rice Bar)	A29-2 (Wheat Bar)	A-20 (Paste)
Omega 6&3 %weight/%weight*							
C08:0 Octanoic (Caprylic)	< 0.01	< 0.01	0.05	C22:4 Docosatetraenoic	< 0.01	< 0.01	< 0.01
C10:0 Decanoic (Capric)	0.13	0.13	0.1	C22:5 Docosapentaenoic	< 0.01	< 0.01	< 0.01
C11:0 Undecanoic (Hendecanoic)	0.01	0.01	0.01	C22:6 Docosahexaenoic	< 0.01	< 0.01	< 0.01
C12:0 Dodecanoic (Lauric)	0.15	0.15	0.12	C24:0 Tetracosanoic (Lignoceric)	0.01	0.01	0.04
C14:0 Tetradecanoic (Myristic)	0.57	0.58	0.44	C24:1 Tetracosenoic (Nervonic)	< 0.01	< 0.01	< 0.01
C14:1 Tetradecenoic (Myristoleic)	0.04	0.04	0.03	C18:2 Octadecadienoic Omega 6	2.27	2.52	13.3
C15:0 Pentadecanoic	0.06	0.06	0.05	C18:3 Octadecatrienoic Omega 6	< 0.01	0.01	0.1
C15:1 Pentadecenoic	< 0.01	< 0.01	< 0.01	C18:3 Octadecatrienoic Omega 3	0.24	0.27	1.49
C16:0 Hexadecanoic (Palmitic)	3.21	3.40	4.03	C18:4 Octadecatetraenoic Omega 3	< 0.01	< 0.01	< 0.01
C16:1 Hexadecenoic (Palmitoleic)	0.07	0.08	0.07	C20:2 Eicosadienoic Omega 6	< 0.01	< 0.01	< 0.01
C17:0 Heptadecanoic (Margaric)	0.04	0.04	0.05	C20:3 Eicosatrienoic Omega 6	< 0.01	< 0.01	< 0.01
C17:1 Heptadecenoic Margaroleic	< 0.01	< 0.01	< 0.01	C20:3 Eicosatrienoic Omega 3	< 0.01	< 0.01	< 0.01
C18:0 Octadecanoic (Stearic)	1.39	1.46	1.41	C20:4 Eicosatetraenoic Omega 6	0.01	< 0.01	< 0.01
C18:1 Octadecenoic (Oleic)	6.23	6.78	5.93	C20:4 Eicosatetraenoic Omega 3	< 0.01	< 0.01	< 0.01
C18:2 Octadecadienoic (Linoleic)	2.27	2.52	13.3	C20:5 Eicosapentaenoic Omega 3	< 0.01	< 0.01	< 0.01
C18:3 Octadecatrienoic (Linolenic)	0.25	0.29	1.59	C21:5 Heneicosapentaenoic Omega 3	< 0.01	< 0.01	< 0.01
C18:4 Octadecatetraenoic	< 0.01	< 0.01	< 0.01	C22:2 Docosadienoic Omega 6	< 0.01	< 0.01	< 0.01
C20:0 Eicosanoic (Arachidic)	0.04	0.03	< 0.01	C22:3 Docosatrienoic, Omega 3	< 0.01	< 0.01	< 0.01
C20:1 Eicosenoic (Gadoleic)	0.01	< 0.01	0.08	C22:4 Docosatetraenoic Omega 6	< 0.01	< 0.01	< 0.01
C20:2 Eicosadienoic	< 0.01	< 0.01	< 0.01	C22:5 Docosapentaenoic Omega 6	< 0.01	< 0.01	< 0.01
C20:3 Eicosatrienoic	< 0.01	< 0.01	< 0.03	C22:5 Docosapentaenoic Omega 3	< 0.01	< 0.01	< 0.01
C20:4 Eicosatetraenoic (Arachidonic)	0.01	< 0.01	< 0.03	C22:6 Docosahexaenoic Omega 3	< 0.01	< 0.01	< 0.01
C20:5 Eicosapentaenoic	< 0.01	< 0.01	< 0.01	Total Saturated Fatty Acids Calc.	5.63	5.93	6.4
C21:5 Heneicosapentaenoic	< 0.01	< 0.01	< 0.01	Total Monounsat. Fatty Acids Calc.	6.35	6.90	6.1
C22:0 Docosanoic (Behenic)	0.03	0.04	0.1	Total Polyunsat. Fatty Acids Calc.	2.54	2.80	14.9
C22:1 Docosenoic (Erucic)	< 0.01	< 0.01	< 0.01	Total Trans Fatty Acid Isomers - GC	1.73	1.89	0.36
C22:2 Docosadienoic	< 0.01	< 0.01	< 0.01				
C22:3 Docosatrienoic	< 0.01	< 0.01	< 0.01	Linoleic:Linolenic Ratio	9.1:1	8.7:1	8.4:1

Table VI: Results (Average of 12 panelists)

	A-28 RICE BAR					A-29 WHEAT BAR				
	APP.	ODOR	FLAVOR	TEXTURE	OVERALL	APP.	ODOR	FLAVOR	TEXTURE	OVERALL
A STORED 24 MONTHS @ 80ºF	6.9	6.8	6.8	7.0	6.7	7.0	6.7	6.6	6.8	6.8
B STORED 4 MONTHS @ 100ºF	6.2	6.5	6.2	6.8	6.2	6.0	6.1	6.1	6.5	6.1
C CONTROL STORED @ -10ºF	6.2	6.5	6.2	6.8	6.2	7.0	6.8	6.8	6.7	6.7
D STORED 6 MONTHS @ 100ºF	6.1	6.1	5.6	6.7	5.6	6.5	6.3	6.0	6.5	6.1

	A-28 RICE BAR PORRIDGE					A-28 WHEAT BAR PORRIDGE				
	APP.	ODOR	FLAVOR	TEXTURE	OVERALL	APP.	ODOR	FLAVOR	TEXTURE	OVERALL
A STORED 24 MONTHS @ 80ºF	6.8	6.8	6.9	6.8	6.8	6.9	6.7	6.7	6.8	6.8
B STORED 4 MONTHS @ 100ºF	6.5	6.5	6.3	6.6	6.3	6.0	6.2	6.0	6.5	6.0
C CONTROL STORED @ -10ºF	6.9	6.7	6.8	7.0	6.8	6.6	6.5	6.8	6.5	6.8
D STORED 6 MONTHS @ 100ºF	5.9	5.9	5.6	6.1	5.7	6.0	6.2	6.0	6.0	5.9

	A-20 PASTE				
	APP.	ODOR	FLAVOR	TEXTURE	OVERALL
A STORED 24 MONTHS @ 80ºF	7.0	6.5	6.8	6.4	6.7
B STORED 4 MONTHS @ 100ºF	6.9	6.4	6.6	6.3	6.7
C CONTROL STORED @ -10ºF	7.0	6.9	7.0	6.5	7.0
D STORED 6 MONTHS @ 100ºF	6.7	6.1	6.4	6.3	6.4

Figure 1. Vitamin Retention in A-28 (Rice Bar) throughout Six Months Storage @ 100ºF

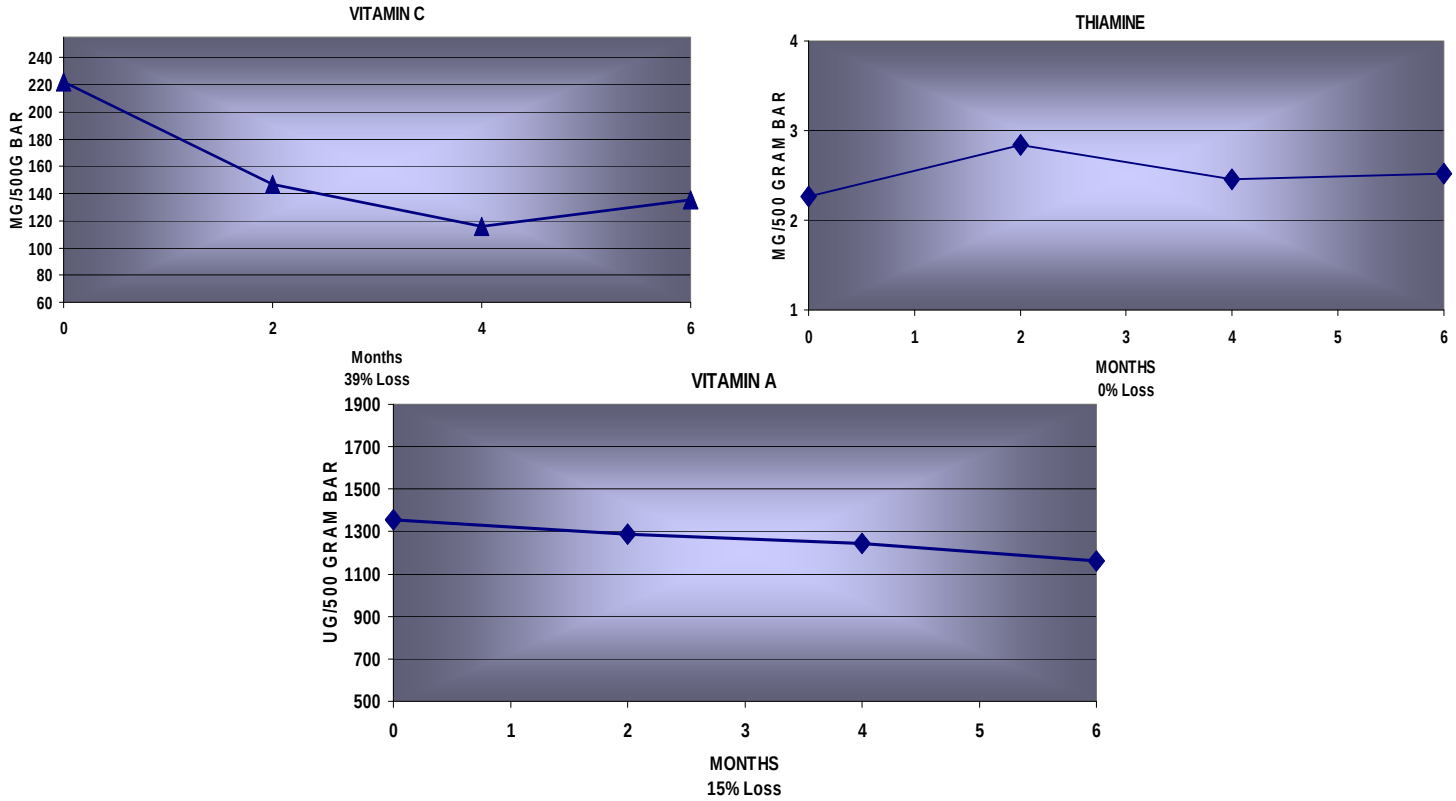


Figure 2. Vitamin Retention in A-29 (Wheat Bar) throughout Six Months Storage @ 100ºF

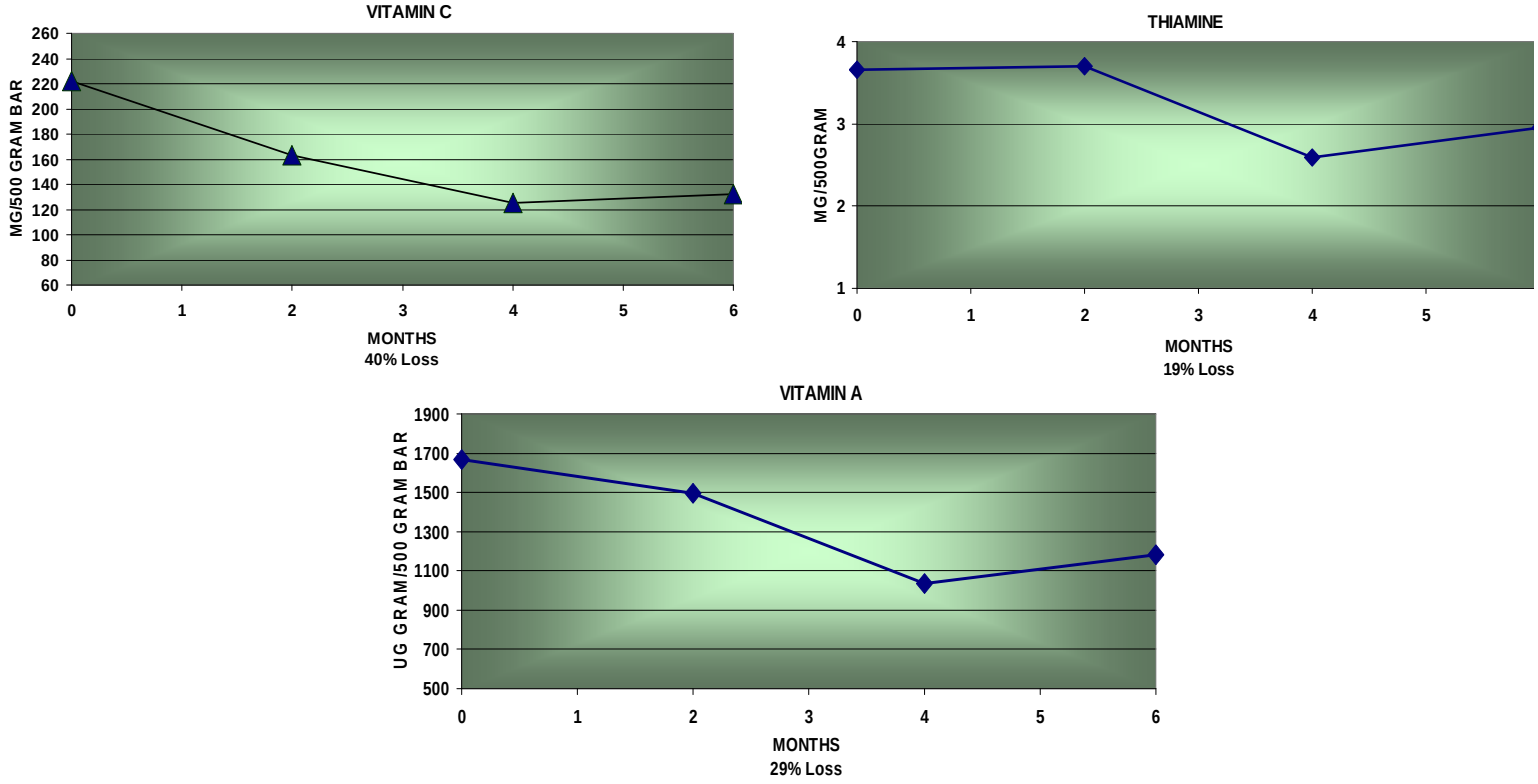
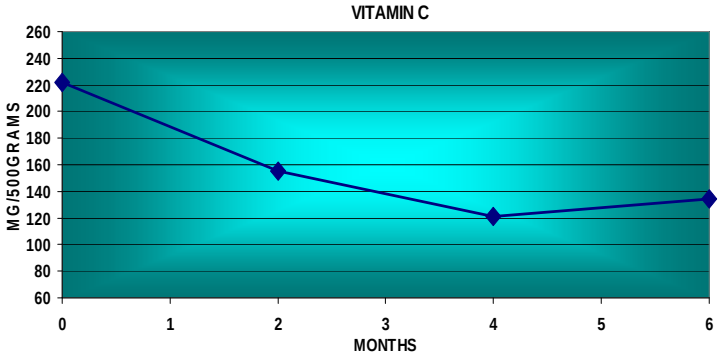
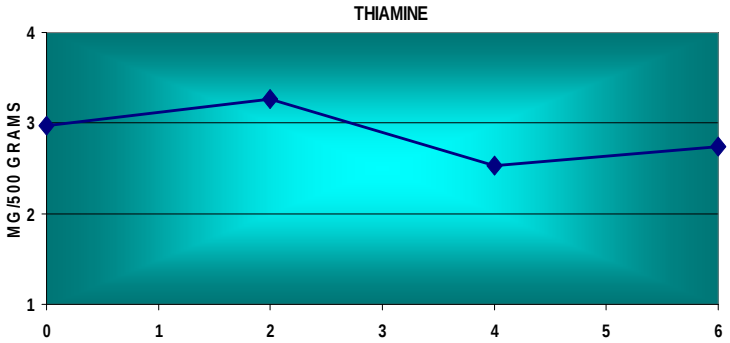


Figure 3. Average of A-28 & 29 (Rice Bar and Wheat Bar) Six-Month Storage @ 100ºF





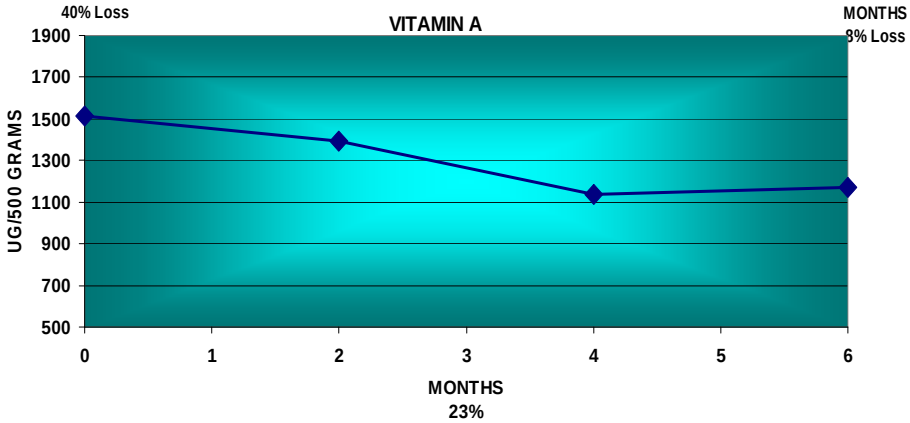
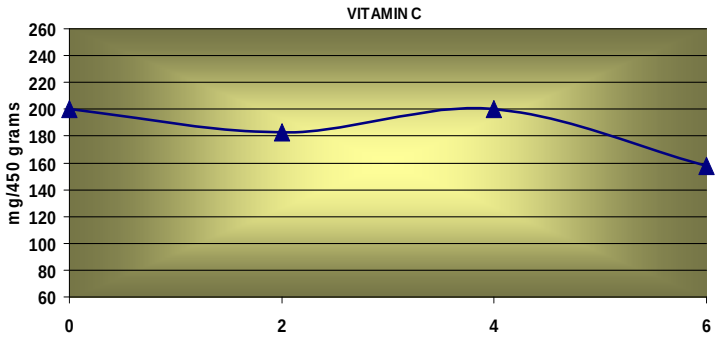
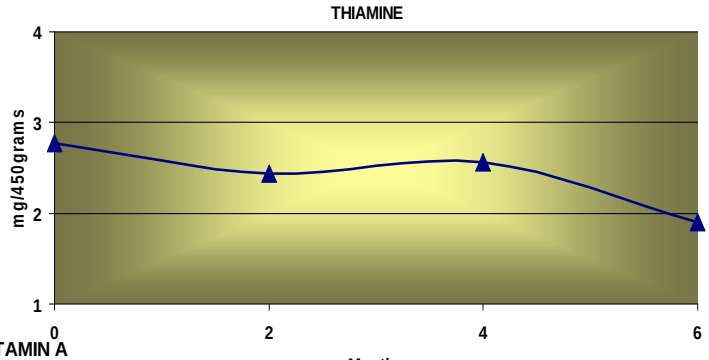


Figure 4: Vitamin Retention in A-20 (Paste) throughout Six Months Storage @100ºF





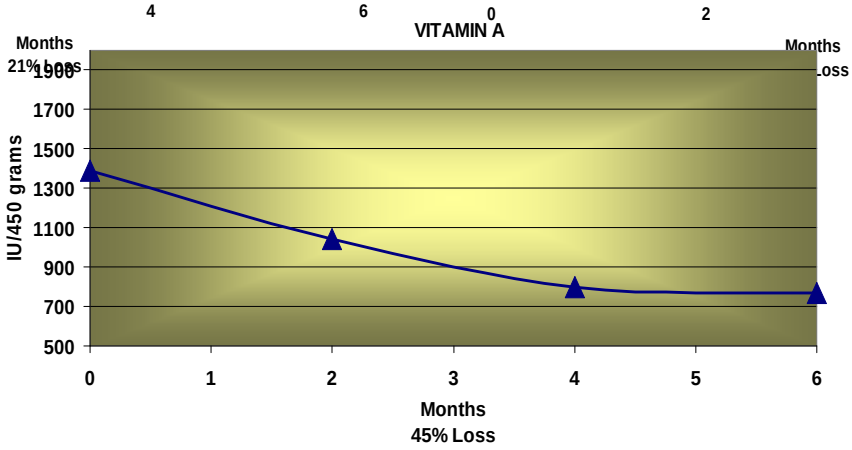


Figure 5: Vitamin Retention in A-28 (Rice Bar) Throughout 24 Months Storage @ 80ºF

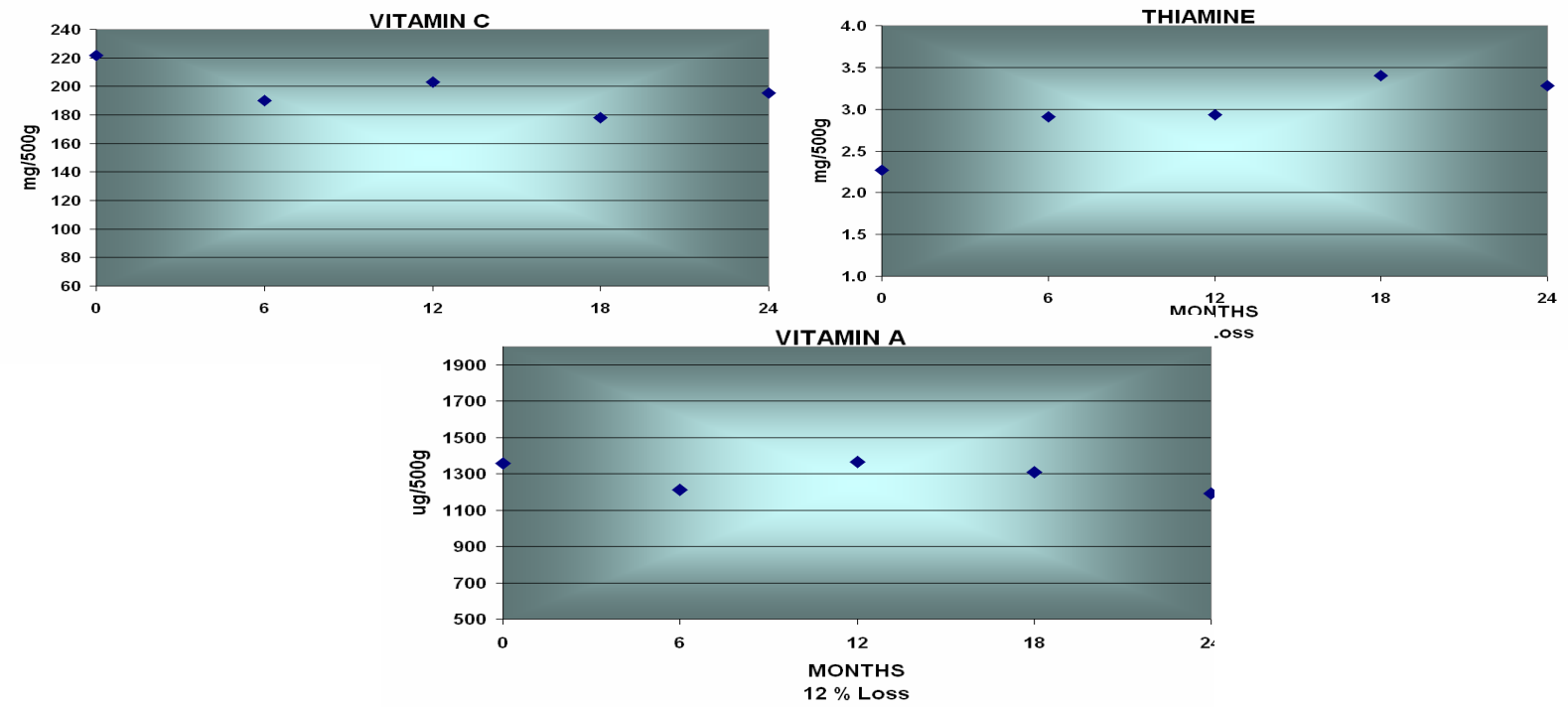


Figure 6: Vitamin Retention in A-29 (Wheat Bar) Throughout Twenty-Four Months Storage @ 80ºF

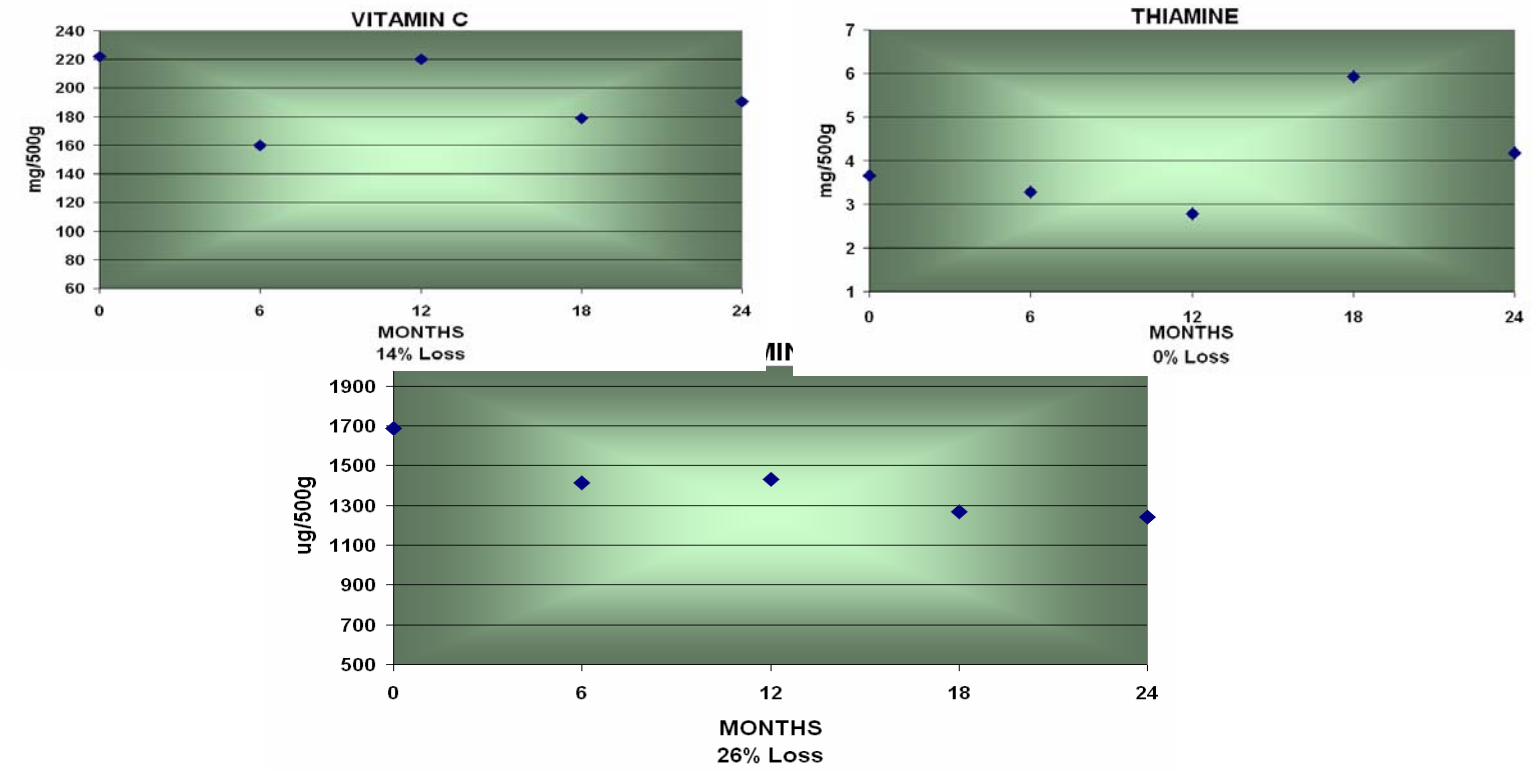


Figure 7: Vitamin Retention in Average of A-28 & A-29 Throughout 24 Months Storage @ 80ºF

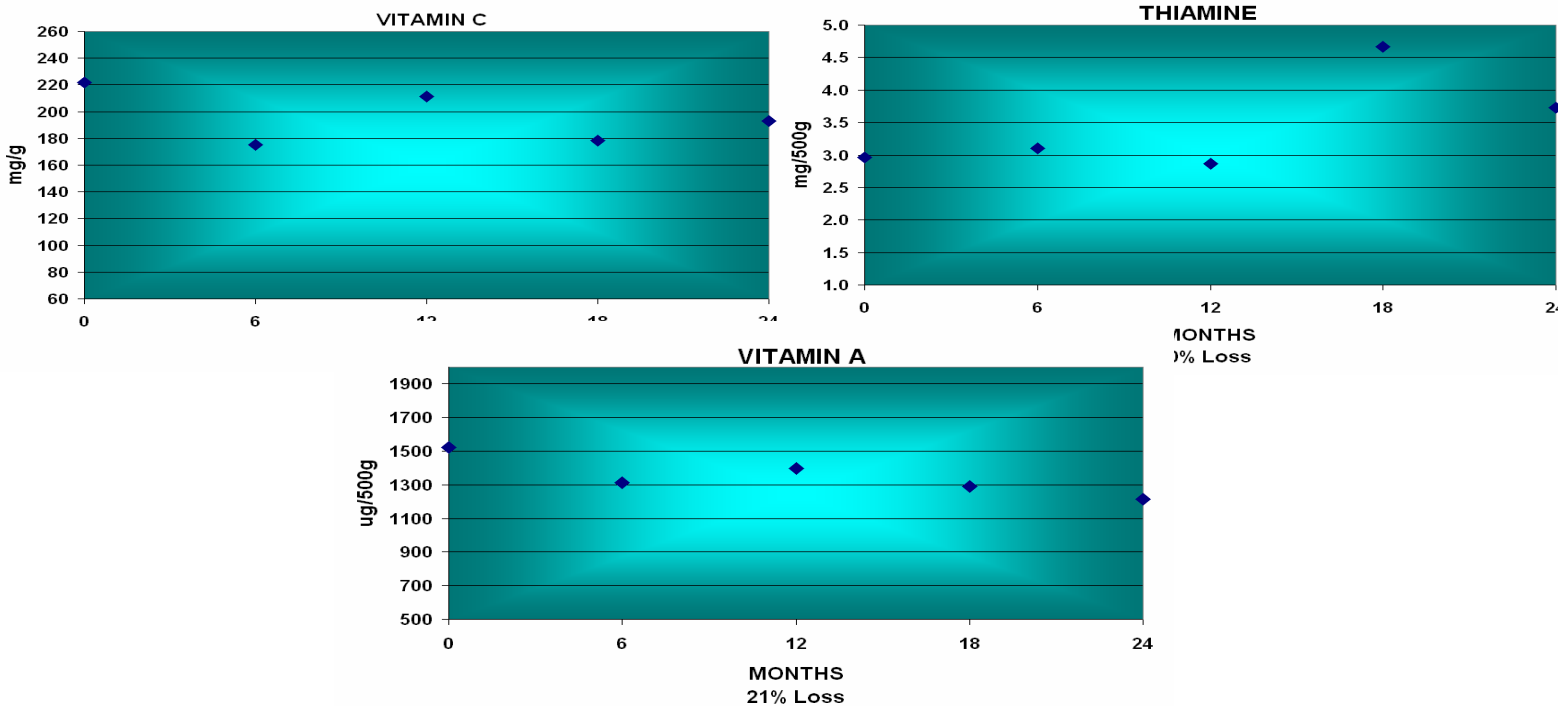


Figure 8: Vitamin Retention in A-20 Paste's Throughout Twenty-Four Months Storage @ 80ºF

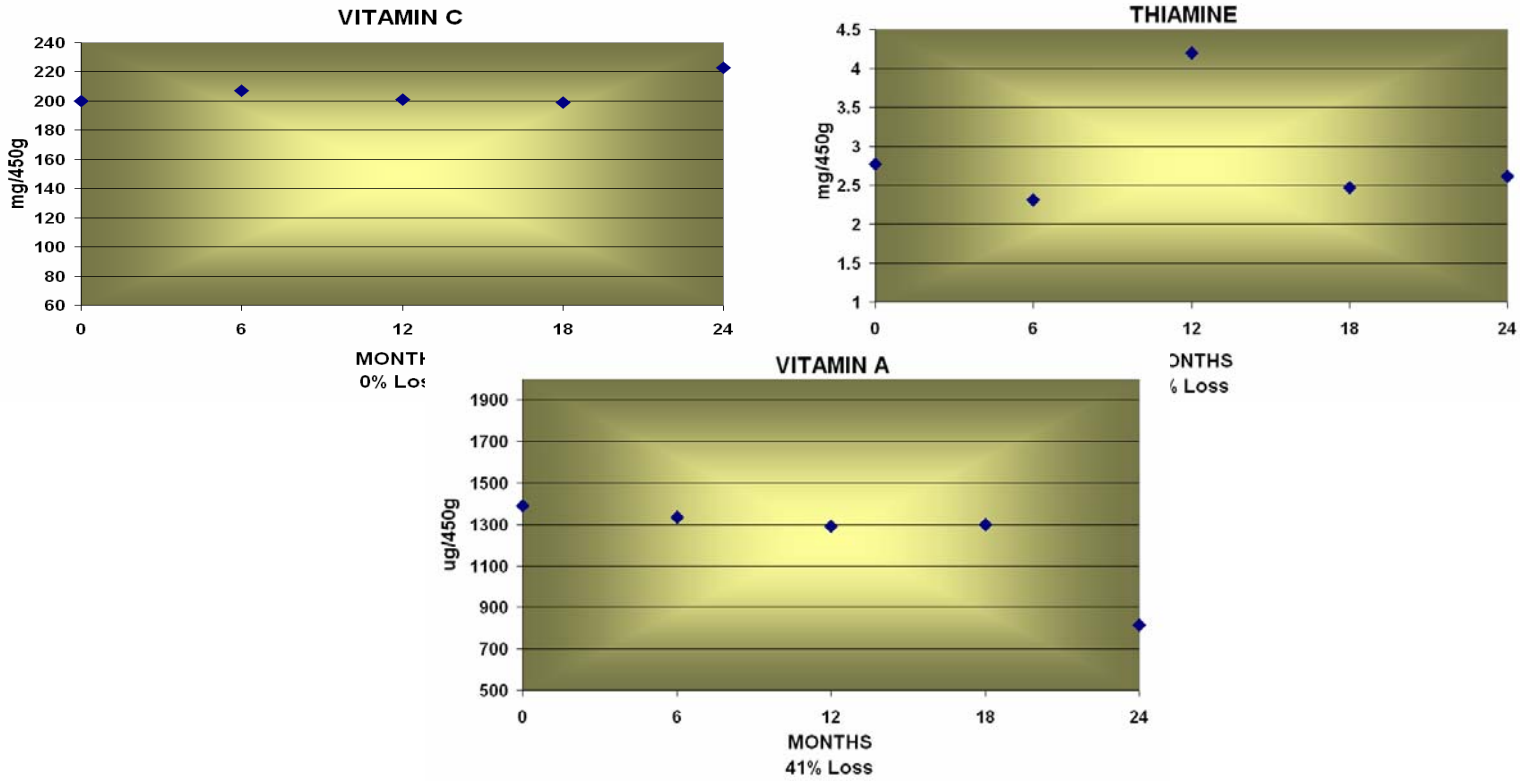


Figure 9: Breaking strength (hardness) of A-28 and A-29 over six months @ 100ºF. These bars are representative of the products that were field evaluated by USAID in 2005.

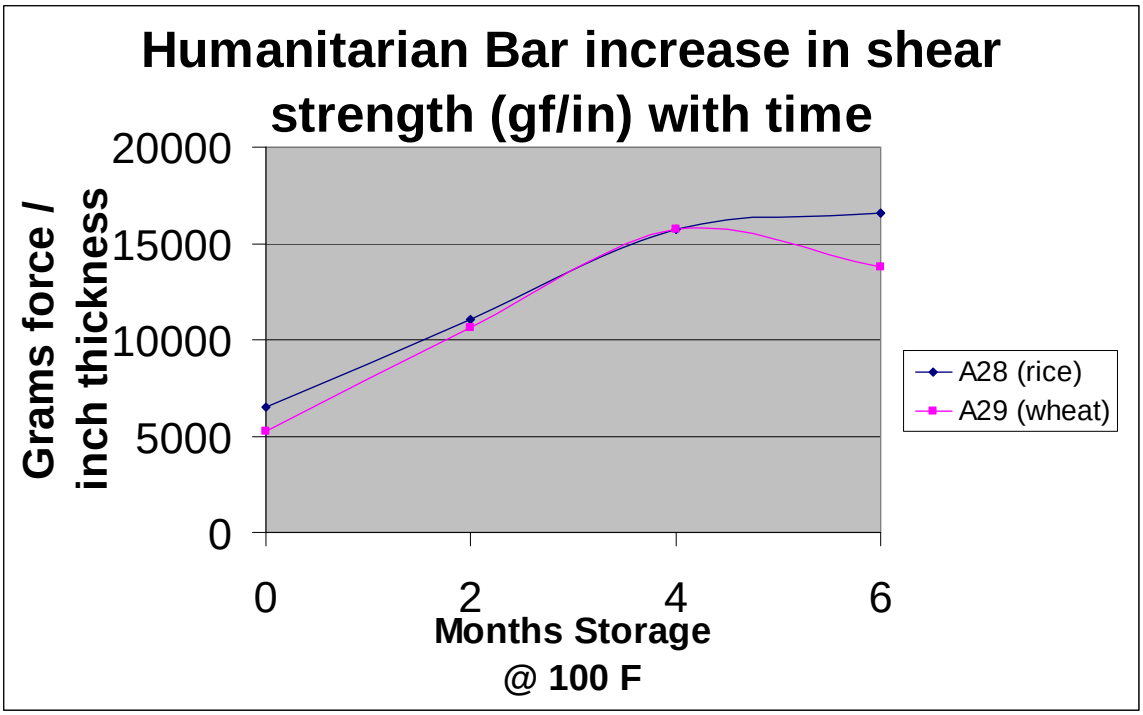


Figure 10a: Sensory Evaluation of A-20, A-28, A-29. The products were judged according to a hedonic rating scale 1-9. Following are the product description, example of the hedonic rating form, and the results.

Product description given to each panelist.

UNITED STATES AGENCY FOR INTERNATIONAL DEVELOPMENT (USAID) EMERGENCY FOOD PRODUCT (EFP)

You are testing emergency food bars that have been developed for use as sustenance to refugee populations that are on the move due to civil disturbances (civil war, insurgency, etc.). These populations require a daily ration that can fulfill all their nutritional needs for up to two weeks until a more permanent food supply can be established.

USAID's organoleptic guidelines for the products are:
1. No distinct flavors such as lemon, vanilla, cherry, chocolate, etc.
2. Overall mild to bland flavor profile and moderate sweetness level.
3. Targeted flavor profiles are grain-based (wheat/rice with a hint of dairy/milk flavor).

You will be testing the product in bar form and as a gruel/porridge made up of the crumbled bar dispersed in water. Attempt to rate these products as if you were the target customer (refugee populations in predominately underdeveloped countries).

Figure 10b: Example of the Hedonic rating form

TESTER: **DATE: January 11 2007**

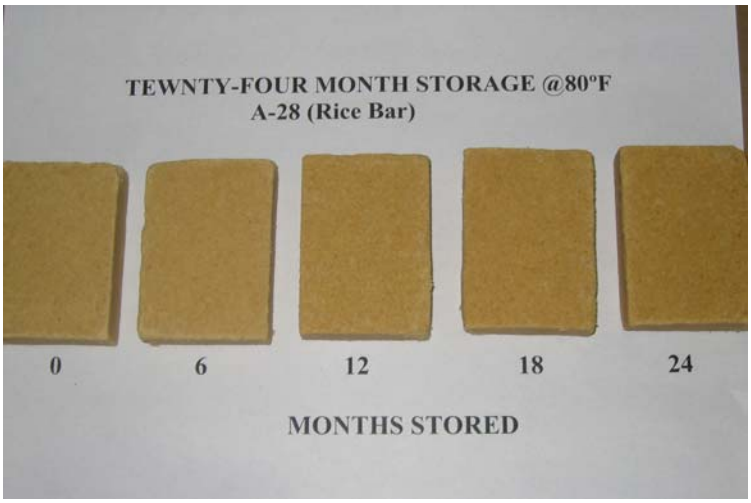
PRODUCT: USAID HUMMANITARIAN EFP PRODUCT *PASTE*

INSTRUCTIONS: **Please indicate number for quality scores in the box and make comments in the remaining space.**

REJECT			***BORDERLINE***		***ACCEPT***			
Extremely Poor	Very Poor	Poor	Below Fair Above Poor	Fair	Below Good Above Fair	Good	Very Good	Excellent
1	2	3	4	5	6	7	8	9

MENU ITEM	APPEARANCE	ODOR	FLAVOR	TEXTURE	OVERALL QUALITY
A	Comments	Comments	Comments	Comments	Comments
B					
C					
D					

Figure 11: Photographs of A-28 and A-29 Bar Variables stored for six months @ 100ºF (upper) and 24 months @ 80ºF (lower). (Note: Two-month samples for 100ºF were lost.)



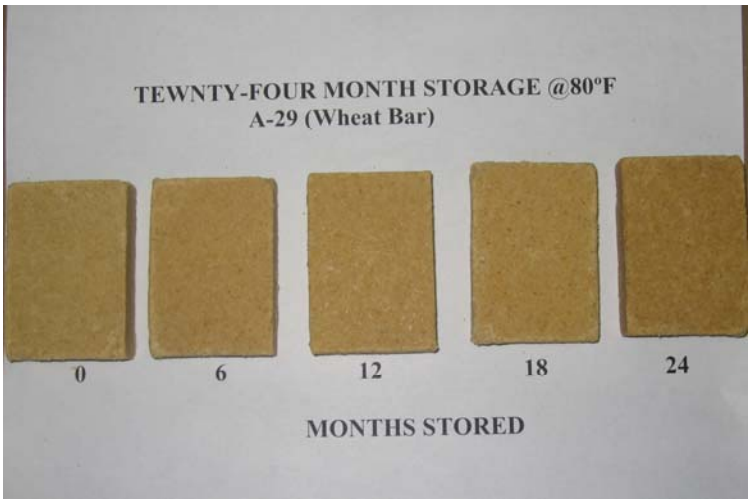


Figure 12: Photographs of A-20 paste stored six-months @ 100ºF (upper) and 24 months @ 80ºF (lower). (Note: Two-month samples for 100ºF were lost.)

ATTACHMENT II:
FINAL DROP TEST SYNOPSIS

As part of the evaluation, USAID requested a determination of the airdrop survivability of the three products, in the event that air delivery were the only safe means to expeditiously provide relief to the refugee populations 'on the move'.

I. TYPES OF DROP TESTS PERFORMED :

A. Simulated Low and High Velocity Airdrops conducted at the Natick Soldier Center from a drop tower asset.
B. Free fall: Terminal Velocity Airdrop and Low Velocity Airdrop conducted at U.S. Army Yuma Proving Ground.

A. Simulated Low Velocity Drop Test Results (NSRDEC):

Personnel from the Combat Feeding Directorate (CFD) familiar with the EFP met with members of the Aerial Delivery Engineering Team and developed a protocol under which the individual cases of the various production test quantities could be assessed for survivability when tested from a drop tower asset at the Natick Soldier RDEC.

The compressed bars (A28 and A29) were packaged in the following manner: regular slotted container (RSC), with outside dimensions of 12"x12.75"x6.375", weighing 28.5 lbs. The paste variable (A-20) was packaged as follows: RSC, outside dimensions of 9.625"x12.75"x14.5", weighing 22.5 lbs.

The drop tower has proven to be a valuable tool in predicting/assessing survivability rates for low-velocity drops (parachute assisted drops) of military rations and other assets. The standard terminal velocity of a parachute-assisted drop is 28.5 ft./s which under normal conditions can be achieved from a free-fall height of 12.6 ft. The free-fall test heights for our drop tower test were 36ft. and 64ft., which yielded impact velocities of 48 ft./s and 64 ft./s, respectively.

1. Results:

a. Compressed Bars (A28 and A29):

Both rations of compressed bars were tested from both test heights in commercial fiberboard packaging (200 lb. bursting strength) and in the Natick fabricated fiberboard box (275 lb. bursting strength). The survivability of all bars tested was 100% (see figures 1 and 2). In other words, all compressed bars dropped were considered consumable since primary packaging was not compromised.

Figure 1

Figure 2

b. Nutrient Paste (A-20):

The paste ration yielded good results as well, however a small percentage of product failed at all drop heights and packaging configurations. The results are as follows: 94.5% survivability at 36 ft. in commercial fiberboard (200 lb.), 90% survivability at the 60 ft. drop height (Natick boxed, 200 lb. fiberboard) and 98% survivability at the 60 ft. drop height (Natick boxed, 275 lb. fiberboard).

Figure 3

Figure 4

Given that our test parameters exceeded the standard parachute systems for low-velocity drops, one can assume that our EFP rations could not only survive the standard low-velocity drops (28.5 ft./s) but would also hold up well in high-velocity air drops (60-90 ft./s) as well. It was even proposed that the EFP rations may be able to hold up in a free-fall drop, which would entail drop speeds of 180-220 ft./s, depending on altitude.

2. Recommendations:

Based on the results gathered from this simulated drop test, CFD packaging personnel have formulated some recommendations that would give the EFP products the best chance of surviving higher velocity/impact drop tests. CFD would recommend the following consideration be given to ensure that boxes for packing the EFP rations are constructed of 275 lb fiberboard boxes, that snug fitting containers are specified, that H-tape closure be specified for both box set-up and top closure, and that fiberboard pads be used between stacked tiers of paperboard boxes in the A-20 paste shipping containers. It is in our best estimation that these added specifications would increase survivability rates at higher impact velocities.

B. Airdrop Test (U.S. Army Yuma Proving Grounds, AZ):

The Aerial Delivery Engineering Team in collaboration with the CFD personnel developed a protocol under which a survivability assessment of EFP rations (bars and paste) could be ascertained when dropped from an aircraft asset at the U.S. Army Yuma Proving Grounds in Yuma, Arizona.

The compressed bars (A28 and A29) were packaged in the following manner: regular slotted container (RSC), with outside dimensions of 12”x12.75”x 6.375”, weighing 28.5 lbs. The paste variable (A-20) was packaged as follows: RSC, outside dimensions of 9.625” x 12.75”x14.5”, weighing 22.5 lbs. All variables were tested in their commercial packaging and were not repacked in stronger/better fitting fiberboard boxes.

1. Results:

During these airdrop tests, EFP rations were dropped from a C140 aircraft in multiple configurations. The first test was a low-velocity, parachute-assisted drop in which the EFP rations were rigged in straight (just EFP rations) and mixed (EFPs combined with other products) load configurations. Both rations performed within the scope of low velocity (28.5 ft./s) without incident and were considered 100% survivable. No additional packaging or precautions were initiated to support the original container packaging.

Both EFP rations were further tested through the free-drop method (worst-case scenario) and the assessment was as follows: each variable was airdropped in its original shipping container (200 lb. fiberboard case), the paste ration suffered approximately 60% failure (see figures five and six below) while the bar rations suffered significantly less (no data available at this time). The airdrop for this assessment was conducted at 1,000 ft. above ground level (AGL) to ensure the effects of transitioning from the aircraft (horizontal velocity) were allowed to dissipate while also achieving terminal velocity (180 fps at sea level).

Figure 5

Figure 6

During a follow-on free drop test, EFP rations were airdropped by emptying the individual daily rations (both types) from their original fiberboard case, dropping them off the ramp of the aircraft while flying at 1,000 ft. AGL. This, again, allowed the loads to dissipate the effects of transitioning from the horizontal to the vertical rates of descent and to attain terminal velocity. The individual meal shape and weight allowed some drift of the meal and also produced some drag, thereby the meal’s terminal velocity was less than 120 ft./s (calculated). This exact rate of descent was not measured. Both the bars and the paste rations survived with minimal damages and both, 100%, were considered consumable (some samples lost vacuum packaging due to pinholes from impact – see figures seven and eight).

Figure 7

Figure 8

2. Recommendations:

Based on the testing conducted, all rations survived low-velocity, parachute-assisted drops with little to no damage to the primary packaging, and this would result in EFP rations that would be considered 100% consumable. Both the simulated and true low velocity drop tests confirmed that the bars as constituted could survive impact velocities of up to 64 ft./s without any failures. The paste variables were somewhat more insubstantial and require additional packaging and/or padding to equal the survivability rates of the bar variables.

Under the worst-case scenarios, where the product would be free-fall dropped at an altitude high enough to reach vertical terminal velocity, both variables did not perform well when dropped in their commercial fiberboard case. A substantial amount of the paste's and bar's primary packaging failed and yielded an inedible product. When you combine these high failure rates with the potential for collateral injury/death to refugee populations on the ground, it is clear that this mode of delivery **should only be utilized under extreme circumstances**. If said delivery method must be used, then the EFP products should be removed from their fiberboard cases and dropped as individual rations to facilitate a lower terminal velocity and increase their inherent chances of survival.

ATTACHMENT III
SCOPE OF WORK

Background

The U.S. Agency for International Development (USAID), through the Bureau for Democracy, Conflict, and Humanitarian Assistance (DCHA), assists foreign countries in famine and disaster relief by providing food rations for distribution. The Department of Defense (DOD) in emergency situations gives similar humanitarian aid. This emergency food relief is often the only source of food available to affected individuals during the initial period after natural disasters, such as hurricanes or earthquakes, and civil disturbances. Therefore, the energy value, nutritional composition, and sensory appeal of such emergency food rations are of utmost importance in meeting the nutritional needs of recipients. Whereas bulk/bagged food commodities are routinely provided through U.S. Government food assistance programs for disaster-affected populations, these foods are difficult to make available in the periods immediately after rapid on-set emergencies. They require storage, means of preparation and delivery time often unavailable to affected people on the move from place to place.

Over the past two years, specifications for an emergency food product useful in these situations were developed by the National Academy of Sciences' Institute of Medicine, Committee on Military Nutrition through an agreement between the U.S. Army Military Operational Medicine Research Program and USAID. This design for the food was published in March 2001 in the document "High-Energy, Nutrient-Dense Emergency Relief Food Product" and is available at http://www.nap.edu/catalog/10347.html . USAID is now seeking to produce prototypes in accord with this design and to test them in real field situations before seeking to procure them in mass quantities for pre-positioning and use in emergency situations around the world.

Purpose and performance requirements

The U.S. Army Soldier Biological and Chemical Command (SBCCOM) Combat Feeding Program will produce, test and deliver three prototypes of the emergency food product (EFP) specified below. The prototype products shall meet all of the following performance specifications for a high-energy, nutrient-dense product detailed in the NAS/IOM report as follows:

1. Satisfies all nutrient requirements for a population of all ages over 6 months as the sole source of subsistence in the initial stages of an emergency, 3 to 7 days with maximum use of 15 days, as shown in Table 1 (p. 15). Minor adjustments may be made to achieve palatability, shelf-life and cost requirements specified below.

2. Is acceptable to nearly all people in the major ethnic and religious groups. Specifically it is palatable (meets minimum hedonic acceptance over the life of the product or scores at least 5 on a 9-point scale using appropriate SBCCOM/CFP taste panel methods), and it contains no ingredient known to be widely unacceptable on ethnic or religious grounds.

3. Is a portable and ready-to-eat product that is convenient to use for populations on the move.

4. Can be stored for at least 30 months at 21ºC (70ºF) within the limits of the palatability and cost requirements herein. (NB: this will not be validated until completion of 6 month 100°F storage study and sensory evaluations.)

5. Can withstand low-altitude air drop without damaging the integrity of the product.

In addition, the supplier shall choose ingredients and processing methods in an effort to achieve a price target of not more than $3,500 per metric ton when USAID seeks to procure the product from the

private market. Although USAID recognizes that the final market price fully under SBCCOM control. This price must be considerably less than the cost prototype production cost represented in this agreement.

In short, the EFP must be safe, palatable, easy to dispense, easy to use, nutritionally complete and cost effective.

Recommended Technical Specifications

The following specifications are derived, with minor modifications, from the NAS/IOM publication: *High-Energy, Nutrient-Dense Emergency Relief Food Product.* Innovative modifications are encouraged in these specifications if they better meet the above performance specifications. For example, formats in addition to the "bar" configuration would be considered.

Appearance

---Exterior: The EFP will be a product of a rectangular, square or other shape that facilitates efficient packing. The color will depend on the ingredients and processing methods used. Artificial colors are not recommended, and it is required that the product not be white or cream-colored. The product, if dispersed in water, must not resemble milk.

---Interior: The EFP could be a compressed, cold-extruded, or baked product of essentially uniform composition, but other options could be explored.

---General: The packaged EFP shall be free from foreign material such as, but not limited to, dirt, insect parts, hair, wood, glass or metal. The product shall show no evidence of excessive heating (materially darkened or scorched).

Odor and Flavor

---The EFP shall be slightly sweet with blended cereal flavor from the base ingredients, and no distinct flavor notes attributable to the protein source or vitamin and mineral additions may be present. Flavorings may be used, but should not be strong or unusual (i.e., not targeted for a specific population).

---The EFP shall be free from foreign odors and flavors such as, but not limited to, burnt, scorched, rancid, sour or stale.

Texture

The texture of the EFP will depend on the ingredients and processing methods used. When crumbled, particle size should be large enough to make a porridge-like product when dispersed in water, and not small enough to resemble milk. The EFP shall be sufficiently firm and resilient to withstand delivery via various modes of transportation (air, land and sea), including low-altitude airdrop. It must maintain structural integrity through short periods of extreme temperatures.

Size

The EFP dimensions shall be such that a unit will deliver 2,100 kcalories and be divided into nine equal parts or sub-units, each part shall be dividable into two equal portions. If the product is a bar, each of the nine bars would be scored down the middle. Each portion will contain approximately 116 kcalories. The total net weight of the unit (2,100 kcalories/EFP) shall be approximately 450 grams (approximately 50 grams/EFP per bar or other form of sub-unit).

Acceptability

Prototypes of the finished product shall be tested using (SBCCOM, CFP) technological panel and must receive a hedonic score of 5.0 or better on a 1.0 to 9.0 point scale, where 9.0 represents "like extremely."

Nutrient Content[4]

The nutrient content is described in table 1 (attached). The overall description is:

---Energy content: The EFP shall be designed as a 2,100 kcalorie unit.

---Moisture content : Moisture shall not be greater than 9.5 percent. Water activity shall not be greater than 0.6.

---Protein content: Protein shall be not less than 63 or greater than 80 grams/2,100 kcalories/unit (7 to 9 grams/ERP bar). The protein must have a minimum Protein Digestibility-Corrected Amino Acid Score of 0.9-1.0.

---Lipid content: Lipids must be not less than 18 percent and not more than 24 percent by weight (approximately 82 to 108 grams/2,100 kcalories, or 9 to 12 grams/EFP bar). Translated into lipids as percent calories: 35 and 46 percent respectively. This may be exceeded only to meet food energy requirements, with due diligence to impact on organoleptic properties. The source of lipids must not be lard, tallow, other animal fats or similar animal-based products. The ratio of linoleic to alpha-linolenic acid shall be 5:1 to 10:1.

---Carbohydrate content: The remaining kcalories will come from carbohydrates as specified in Table 1 (p. 15).

---Vitamins and minerals: As specified in Table 1. [NB: some vitamins and minerals may need to be coated or encapsulated to ensure stability. Examples are: vitamins A, E, C, iron, copper, manganese, selenium, zinc, chromium.

---Caloric density: Must be between 233 and 250 kcalorie/50 gram bar (2,100 kcalories/unit product.

Additives

Any use of additives must be consistent with guidelines of both U.S. Food and Drug Administration (FDA) and Codex Alimentarius, and comply with the specifications set forth in the Food Chemicals Codex (National Academy Press, Washington D.C.).

Prohibitions

The EFP shall contain no sensitive ingredients that would limit its intended use for diverse populations. No alcohol shall be incorporated in it, nor any meat products used. Also, supplementation with amino acids is not recommended. In addition, it is recommended that food containing known allergens, e.g. peanuts, be avoided. Genetically modified (GMO) food ingredients should be avoided.

Processing Recommendations

[4] The EFP is intended to be an initial emergency food to be used no longer than 15 days while a more permanent food supply line is put into place. If cost is a consideration, it is recommended that food ingredients be analyzed for nutrient content and supplemented only as necessary. It should be assumed that the recommended amounts and sources are considered optimal, but other factors may take precedence in the final formulation.

---The product shall be prepared through extrusion, compression technology or baked.

---Units will be prepared consisting of nine bars or other sub-units of approximately 233 kcalories each, with central scores that allow easy division to 116 kcalorie portions.

---It is desirable that the EFP be amenable to being made into gruel by crumbling the bar and mixing with potable water.

Packaging Recommendations

The EFP will be subjected to environments that exhibit a wide range, including extremes of temperature and humidity, and to delivery conditions that will often be characterized by lack of infrastructure. Therefore, all packaging components must be capable of withstanding temperature and physical abuse. In addition, the EFP will be delivered using all modes of transportation, including airdrop. Separate packaging, or more likely, additional packaging, may be employed for airdrop requirements.

Primary Packaging: Each 2,100 kcalorie daily EFP unit will be prepared as nine equal-sized bars or other sub-units. If bars, each would be centrally scored to allow breaking into two segments. The bars will be individually wrapped to facilitate handling, while reducing contamination to additional bars, through human, insect, animal or microbial intervention. The primary wrap need not be a barrier material, and it is recommended that the coating be polyolefin or wax-based paper. This primary package, after use, may also serve as a combustible energy fuel source**.**

Secondary Packaging: A daily supply of nine units will be packaged under a nitrogen flush or a vacuum, into a barrier package, to enhance product shelf life. The secondary packaging will be a pouch construction of trilaminate construction: from inside to outside, 0.003 to 0.004-inch thick polyolefin, 0.00035 to 0.0007-inch thick aluminum foil, and 0.0005-inch thick polyester or nylon. The pouch material shall be FDA-approved for food use and shall show no evidence of delaminating or degradation when heat-sealed or fabricated into pouches. Pouches that contain the nine units may be preformed or formed on line. The pouches will have an inside dimension sufficient to hold the nine individually wrapped units. The pouch shall be made by heat-sealing three edges (two sides and bottom) with 3/8-inch (+/- 1/8 inch) wide seals and in a manner that will ensure hermetic seals. The pouch shall maintain its integrity and air tightness of the side and bottom seals when tested by appropriate methods. The side and bottom seals shall have an average seal strength of not less than 6.0 lb/inch. V-, C- or U-shaped tear notch at least 1/32-inch deep, located 3/4 to 1 inch from the top edge of the pouch (excluding the lip) shall be made on one or both side seals. The distance between the inside of the tear notch and the inside edge of the seal shall be no less than 1/8 inch. One side of the open end of the pouch may be provided with an extended or fold-over lip, extended not more than 1/8 inch (+/- 1/16 inch) to facilitate opening and filling. In order to discourage diversion of the product, the pouch must be of a neutral color (e.g. off-white, tan); no bright, attractive colors or shine may be used.

A set of five EFP units, sufficient for a 5-day supply of nine 2,100 kcalorie rations, could be packaged together and constitute the distribution unit as a "bundle." The five trilaminated pouched units could be bundled into a low-density polyethylene bag to provide either a 5-day individual EFP supply or a daily ration for a family of five members. The film used to prepare the bundle will be monoaxially or biaxially oriented, with machine direction oriented across the pouch. Filling will therefore be accomplished on a horizontal-wrapping machine. A V-, C- or U-shaped tear (as previously described) shall be made on one or both side seals. The notch will allow easy opening by propagating the notch tear across the bundle bag.

As an alternative, the outer package may be a reusable semi-rigid polyolefin container which could be used for storage and/or water transport.

A third option is to utilize a metal outer package, such as a tinplate box with a cover. The cover shall be easily removable. The container may also have multiple uses, such as storage and/or water carrier.

Tertiary Packaging: Rations will be available in two formats: ground delivery and airdrop.

---Ground delivery: Eight bundles consisting of five pouches each (each pouch contains five daily EFP units) will be placed in a 4 x 2 or appropriate configuration in a corrugated shipping container that constitutes 1 case. Approximately 50 cases will be placed on a pallet. The shipper will be sufficient to contain the rations and allow stacking to five pallets high in similar environmental temperature and relative humidity extremes as experienced in Guam, Italy, and Maryland storage facilities used by U.S. Agency for International Development (USAID).

---Airdrop: EFP Units (five bars or other sub-units each), pouches (five units each) or bundles (five pouches each) may be packaged for low-altitude airdrop using appropriate package protection to simultaneously provide impact protection for the EFP.

Labeling

The secondary and tertiary packaging shall carry simple, graphic instructions on how to open the package and on alternative ways to consume the product (directly or as porridge). A disclosure of the energy nutrient (protein, fat, carbohydrate, ash, and moisture) content by percent and by weight, in metric units, must be made on the basis of a one-day ration (2,100 kcalories). In addition, each pouch and each EFP unit shall carry a complete list of ingredients, the net weight of the unit, in grams, and any other information required by the purchasing Agency.

Ingredients for consideration[5]

---Cereal and other base: corn, oat flakes or flour, rice flour, wheat flour, potato flour.

---Protein base: soy derivatives, milk solids, casein or derivatives.

---Lipid sources: partially hydrogenated soybean or cottonseed oil, flaxseed oil (source of omega -3 fatty acids), canola oil, sunflower oil.

---Sugars: sucrose, glucose, high fructose corn syrup, maltodextrins.

---Baking and leavening agents, if needed.

---Vitamin and mineral premixes as specified in the nutrient profile (see attached table).

The product must be prepared using Good Manufacturing Practices and maintain suitability as a food for the shelf life of the product.

Technical Advisory Committee

USAID will form an interagency technical advisory committee to oversee the technical aspects of the product development. The committee will be co-chaired by Thomas Marchione, nutrition advisor to USAID/DCHA and Samuel Kahn, senior nutrition advisor to the Office of Health, Infectious Diseases and Nutrition in the Bureau of Global Health, USAID. This committee will be periodically consulted on questions and decisions that arise in the development process.

[5] This performance specification is written to facilitate innovation from suppliers. It is recommended that off-the-shelf ingredients and materials be utilized where possible.

Deliverables and Deadlines

U.S. Army Soldier Biological and Chemical Command (SBCCOM) will supply the USAID advisory committee the following deliverables on or before the specified day beginning with the start of this agreement. Assuming both parties sign the agreement by the end of the 2002 fiscal year, the completion date is September 30, 2003.

1. Effective date of agreement is date of authorizing signatures	- day 0
2. Report on proposed prototype specifications and product description	- day 40
3. Reports and models of bench-fabricated prototypes, including data on hedonistic tests and other evaluations.	- day 90-180
4. Report on preliminary accelerated (two weeks at 120°F) nutrition stability test results on vitamins C and A and sensory assessment, and progress meeting/conference call regarding schedule.	- day 210
5. Report on preliminary formulas, material, and manufacturing specifications to be used by SBCCOM for prototype procurement.	- day 220
6. Produce and transport six metric tons of EFPs, comprised of two metric tons each of three different prototypes to a U.S. port designated by the USAID's Office of Food for Peace.	- day 300
7. Provide in writing the detailed generic specification with product formula, ingredients, nutrient content, packaging and manufacturing requirements for each prototype. This must be information sufficient for use by the U.S. Department of Agriculture for competitive procurement from U.S. food processors.	- day 310
8. Report on final nutrition stability at 100ºF for 6 months.	- day 360

USAID will:

9. Select and support the technical advisory committee.

10. Conduct field-testing in three field sites where relief operations are underway through its Food and Nutrition Technical Assistance Project.

At SBCCOM's discretion, products will be placed in storage for extended, 30-month, stability determination.

NUTRIENT	MINIMUM NUTRIENT 2100 kcal	MAXIMUM NUTRIENT 2100 kcal	COMMENTS
Energy kcal	2100	2250	
Protein g	53	74	*PDCAAS >/= 1.00
Fat g	82	108	Sat Fat >/= 10%
			*PUFA, veg oil @7-10%
			*LA:LNA ratio 5:1 to !0:1
Total Carbohydrates g	210-263		
as total sugars g	63-105	131	palability enhancement
as glucose g	18		6g/gNa;from maltodextrins
as lactose g		36	not free but from milk solids
all monosacharides g		53	25%weight of carbohydrates
Sodium (Na) g	2.1	2.1	EFP should not taste salty
Potassium (K) g	2.7	2.7	EFP should not taste bitter
Chloride (Cl) g	3.2	3.2	Equimolar to Na
Phosphorus (P) g	1	1	as nonphytate form
Calcium (Ca) g	1	1.2	as PO4,citrate, CO4 salt
Magnesium (Mg) mg	400	480	primarily food derived
Chromium (Cr) ug	27		
Copper (Cu) mg	1.18	1.41	
Iodine (I) ug	220	480	
Iron (Fe) mg	20	25	suggest NaFeEDTA
Manganese (Mn) mg	2.9	3.5	
Selenium (Se) ug	60	72	selenomethionine form
Zinc (Zn) mg	22	24	as sulfate or acetate;
			Zn:phytate molar ratio <15
Vitamin A ug	1,050	2,100	does not include carotene
Vitamin D ug	11	12	cholecalciferol form
Vitamin E mg	34		0.6mg/g PUFA
Vitamin K ug	120		
Vitamin C mg	210	420	encapsulation required
Thiamin mg	2.5	3	
Riboflavin mg	2.5	3	
Niacin mg	23.6	26	max refers to added nicotinic acid
Folate ug	406	447	max refers to added folic acid
Vitamin B12 ug	25.2	30.2	
Pantothenic Acid mg	8.2	9.8	
Biotin ug	50.4	60.5	
Choline mg	769	923	can be provided as lecithin
Moisture %		9.5	

*NOTE: PDCAAS is Protein Digestability Corrected Amino Acid Score
PUFA is PolyUnsaturated Fatty Acid
LA:LNA is Linoleic Acid:Alpha Linolenic Acid Ratio

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