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TECHNICAL REPORT
69-69-FL

FABRICATION OF FOOD BARS BASED ON COMPRESSION AND MOLDING MATRICES

by

Robert L. Pavey

Swift & Co.,
Research & Development Center,
Oak Brook, Illinois 60521

Contract No. DAAG 17-67-C-0068

February 1969

UNITED STATES ARMY
NATICK LABORATORIES
Natick, Massachusetts 01760

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FOREWORD

Both weight and bulk are critical factors in the design of a food supply for the combat soldier engaged in operations in which all food must be carried on his person. Dehydration combines a reliable method of food preservation with a maximum reduction of weight. During the past several years studies have pointed to the feasibility of compressing dehydrated foods to achieve a marked reduction in bulk. Independent studies have shown that many foods when suitably plasticized can be compressed without serious fragmentation and subsequently are restored to normal appearance and texture during hydration. Specialized additives and binding agents are available to insure proper cohesiveness, to control excessive hardness, to adjust caloric density, to stabilize flavor and to diminish the sensation of dryness of compressed bars intended for direct consumption.

This report covers Phase I of experimental effort in which current technology is utilized for the development of a variety of compressed dehydrated food bars which are acceptable for direct consumption and which on rehydration yield familiar foods as normally served. To the combat soldier this objective would provide a safe, highly compact food supply of minimum weight from which can be prepared a variety of normal meal items. However, under circumstances which preclude diversion of time or attention to food preparation, these same bars can be consumed from the compressed state.

This investigation was performed at the Research and Development Center of Swift & Company in Oak Brook, Illinois under a Project titled "Food Processing and Preservation Techniques" (No. 1M624101D553). The Official Investigator for the program was Mr. W. R. Schack. He was assisted by Dr. R. L. Pavey, Dr. H. H. Young, Messrs. D. L. Davies and P. E. Mone and Mrs. A. E. Dethmers. The Project Officer for the U. S. Army Natick Laboratories was Dr. Maxwell C. Brockmann of the Food Laboratory. Dr. Donald E. Westcott served as Alternate Project Officer.

TABLE OF CONTENTS

List of Tables

ABSTRACT

Dried foods, plasticized to prevent fragmentation, were compressed with appropriate binders into bars of approximately equal size, density and caloric content (140 + 14 kcal/bar). Bars representing the following food items were designed, formulated, fabricated and evaluated for physical, chemical and sensory characteristics after storage for 3 months at 38°C: (1) beef stew; (2) chicken and rice; (3) barbecue pork; (4) chili with beans; (5) shrimp creole; (6) chicken ala king; (7) tuna salad; (8) scrambled eggs with bacon; (9) mixed creamed vegetables; and (10) apple pie filling. Complete information on all formulations and processing is supplied.

In accordance with design requirements bars were rated by a taste panel as acceptable for consumption from the dry-compressed state and for consumption after rehydration for 20 minutes in water at 80°C (25°C for items consumed at room temperature). Bars were evaluated for cohesiveness, dimensional stability under pressure, ease of shear by the incisors and subsequent mastication. Observations on free fatty acids, peroxide value and browning (reflectance units) are recorded for each bar at the time of fabrication and after the referenced storage.

Introduction

The purpose of Phase I of this contract was to develop and describe commercially feasible processes for the production of ten species of compressed food bars which are acceptable when eaten in the bar form and which can be rehydrated to yield a familiar meal component. The food bars are to be equal in dimension and have an energy content of approximately 125 kcal per bar or higher. The species to be developed are:

a. Beef Stew
b. Chicken and Rice
c. Barbeque Pork
d. Chili with Beans
e. Shrimp Creole
f. Chicken ala King
g. Scrambled Egg with Bacon
h. Tuna Salad
i. Mixed Creamed Vegetables
j. Fruit Pie Filling

Design Parameters for Compressed Bars

A. Composition:

1. Primary ingredients normal to each food item
2. Bars to contain approximately 125 kcal.
3. Binders and additives not to exceed 25 percent by weight of the basic composition.

B. Physical Requirements:

1. All bars rectangular and dimensionally equal with thickness and width being approximately 1.3 and 4 cm., respectively.

2. Minimum bulk density of 0.8g per cc.

3. Withstand normal handling and not shatter when dropped on a concrete floor from a height of 2 meters.

4. Remain dimensionally stable within 10 percent when held under a pressure of 0.5 kg per cm^2 for 24 hours at 38°C.

5. Easily sheared by incisors at room temperature and subsequently masticated and swallowed without difficulty.

6. No leakage or obvious fat transfer during such storage.

   Above attributes not significantly altered during storage at 38°C for three months.

C. Chemical Requirements

1. Fat content not to exceed 40% of the total caloric content.

2. Fat rancidity, browning and free fatty acids not to increase more than 100 percent during storage.

3. Rehydration within 20 minutes when added to water of proper temperature for the respective products and with agitation practicable in a canteen cup.

D. Preparation

1. All operations recognized as commercially feasible and practicable.

2. All components recognized as commercially producable.

E. Sensory Characteristics

1. Bars acceptable for direct consumption.

2. Hydrated products from bars shall have characteristics normally associated with its identity and shall receive an average rating of not less than 6 on a 9-point hedonic scale.

3. The above ratings shall not differ significantly (5% level) after storage for three months at 38°C.

Experimental Procedures & Results

A. Product Preparation

The following procedures were used in preparing the ten products required under Phase I of this contract.

1. Component Preparation

The following components required preparation for use in the product formulas:

a. Beef: U. S. good grade beef inside rounds were used. These were trimmed of all heavy connective tissue, discoloration, bruises or other defects and to approximately 10% fat. The trimmed meat was placed in metal cans and sealed under vacuum.

Cooking was performed under 6 psi steam pressure in a retort until reaching 80°C minimum internal temperature. The product was then chilled and held in a -2° to -3°C cooler until prepared for freeze-drying.

b. Chicken: U.S.D.A. Grade A Fryer breast meat without skin was used. This product was examined for bone, cartilage, bruises or discoloration and skin prior to being sealed under vacuum in metal cans. The canned meat was cooked under 6 psi steam pressure until reaching 80°C minimum internal temperature. After chilling, this product was stored in a -2° to -3°C cooler until being prepared for freeze-drying.

c. Pork: Boneless pork loins from meat type butcher hogs were used. These were trimmed of all heavy connective tissue, bruises, discolorations and bone fragments. Fat was trimmed to approximately 10 percent. The trimmed pork was then sealed under vacuum in metal cans and cooked under 6 psi steam pressure until a minimum internal temperature of 80°C was reached. The cooked product was chilled and held in a -2° to -3°C cooler until being prepared for freeze-drying.

d. Ham: The ham used was commercially prepared "Sectioned and Formed Ham" manufactured by Swift & Company for institutional use. This product is water-cooked in metal cans to a 68°C minimum internal temperature, then cooled and held in a -2° to -3°C cooler until prepared for freeze drying.

e. Bacon: The bacon used was commercially prepared "Swift's Premium" sliced bacon. This product was procured, diced 1/4 x 1/4 x 1/16-inch and prefried at the time of product preparation. Frying was accomplished on an electric brazier until reaching a 25 to 28 percent yield resulting in crisp dices but having no burnt particles.

f. Shrimp: Frozen, peeled and deveined Grade A shrimp sized 70 to 80 per pound were used. These were defrosted and cooked in boiling water until done in flavor but with care being taken not to overcook them, which would result in toughness. The cooked shrimp were chilled in running cold water prior to preparing for freeze-drying.

g. Tuna: White albacore tuna packed in water was used. This product was removed from the can and drained prior to preparing the salad mix.

h. Potatoes: Russet potatoes were used. These were peeled and diced into 1/4-inch cubes prior to cooking in water until tender but not mushy. The cooked potatoes were chilled in running cold water prior to freezing for freeze-drying.

i. Peas: Grade A, dark seeded, Perfection variety frozen peas were used. The frozen peas were scarified using an Urschel Scarifier prior to cooking in water until tender but not mushy. The cooked peas were chilled in running cold water prior to being frozen for freeze-drying.

j. Carrots: Grade A, 3/8-inch diced, frozen carrots were used. These were water-cooked until tender but not mushy or over-soft. The cooked carrots were chilled in running cold water prior to freezing for freeze-drying.

k. Corn: Grade A, frozen, sweet, yellow corn was used. This corn was water-cooked until tender but not mushy. The cooked corn was chilled in running cold water prior to freezing for freeze-drying.

l. Rice: Instant white rice was used in these products. The rice was cooked in water and rinsed in cold water prior to using in formulas or freezing for freeze-drying.

m. Red Peppers: Canned diced red peppers were drained and washed in cold water prior to freeze-drying.

n. Mushrooms: Canned diced mushrooms were drained and washed in cold water prior to freeze-drying.

o. Kidney Beans: Kidney beans were cooked until soft throughout but not mushy. These were chilled in cold water prior to freeze-drying. It was found that the skins of these beans either split during cooking or during drying and, therefore, they did not require scarification.

p. Moisture Mimitic Agent: Dry sorbitol was blended with glycerol at 80° to 85°C until becoming stiff in consistency similar to shortening. This blended material was sealed from moisture as soon as it was

blended and then frozen. The frozen material was chopped in a meat cutter with powdered dry ice to keep it frozen. As soon as the material was chopped to a particle size of a flaked powder it was again sealed in jars to protect it from moisture and refrigerated until used. This material so prepared had a melting point of approximately 50°C. and maintained its granular structure at room temperature if not allowed to absorb moisture.

q. Matrix B2: This binding and high caloric density material was prepared in accordance with the procedure prescribed by Pillsbury under contract No. DA19-129-AMC-2103 reported in U. S. Army Natick Laboratory Technical Report, FD-37, 1966. This product was spray-dried and contains 6.2 kcal per gm.

All other components were used as procured and are identified in their respective formulas.

2. Freeze Drying of Components:

Freeze-drying of components for the compressed bar formulas was by conventional methods. The products were first prepared for drying; i.e., meats were diced or ground, as required for the product formula. They were then placed in drying trays and frozen in a plate freezer. The frozen products were freeze-dried using radiant heat of 50°C. maximum temperature. The products were dried until coming to 50°C temperature for a minimum of one hour. Vacuum of the dryer was broken with nitrogen and the dried products sealed in metal cans under nitrogen until used in formula preparation.

3. Formulas for Compressed Food Bars:

All components used in formulating the ten species of compressed food bars are FDA approved. Formulas for each of the ten items are shown in Table I. In most cases the formulas required no preparation other than conditioning and blending prior to compression. The exceptions were the barbecue sauce for pork and barbecue, tuna salad, scrambled egg and bacon, and shrimp creole.

For the preparation of barbecue sauce, the dry sauce ingredients were blended together with two parts water and cooked to 85°C. The cooked sauce was then freeze-dried and ground prior to being added to the conditioned pork for compression.

The tuna salad was mixed together and freeze-dried. The dry material was then conditioned and mixed with the moisture mimetic agent prior to compression.

The egg formula was blended together, cooked in a pasteurizer using water at 77°C and gently stirred until reaching a 72°C. At this temperature the mix had started to coagulate but was still pourable. The cooked egg was then poured into drying trays, frozen and freeze-dried. The dry material was broken up and compressed into bars.

The shrimp creole was blended together and freeze-dried. This dry material was conditioned, the moisture mimetic agent added, and then compressed.

In making the mixed vegetable bar, it was found necessary to include ham to achieve the proper caloric density and still attain proper rehydration of the compression. Table I.

4. Conditioning for Compression:

Dried meat and vegetable materials are quite fragile and normally shatter when compressed. Of various methods studied it was found that the simplest method of moistening with water was most successful. This method of conditioning was to spray the product with water until the desired amount was added. The moisture was then allowed to equilibrate throughout the product for one hour under refrigeration prior to adding the remaining components and compressing. The amount and method of water addition were found to be critical in certain products. In such products it was necessary to avoid direct contact of moisture with the seasoning or sauce components to achieve subsequent rehydration. If moisture reached these components, they would cake or harden to the extent that moisture would not penetrate during rehydration. To avoid contact, only the meat components and/or certain other particulate components of the formulation were conditioned with water. The water levels used were determined, through testing, to provide sufficient moisture to allow compression without major fragmentation, but not enough to have moisture expressed from the particles during compression. The levels of moisture used and the components of each product conditioned are shown in Table II.

5. Compression of Bars:

A compression die and punch assembly was constructed having dimension of 4 cm x 6.5 cm x 22 cm high internally. A press

block was used to prevent compression beyond 1.3 cm minimum thickness of the product chamber. Pressures in excess of that required to compress the product to the desired thickness were absorbed by the rigid press block; therefore excess compression was avoided.

Relaxation of the bars after compression was prevented by vacuum sealing them in foil pouches. Components of products not previously blended prior to conditioning were blended in a Hobart Mixer. The chilled moisture mimetic agent was blended with the other chilled components just prior to weighing and compressing the bars. Conditioned products to be freeze-dried after compression were weighed in amounts to result in the desired dry weight.

Compression was performed on an air-operated hydraulic bench press. Pressures required for product compression were from 500 to 800 psi. Dwell time was approximately 5 seconds for all products. After compression, products not conditioned for compression were vacuum sealed in laminated foil pouches, labeled and held in 40°C cooler until packed and shipped. Products conditioned prior to compression, and therefore requiring freeze drying, were also vacuum sealed in laminated foil pouches and frozen. This was done to prevent relaxation prior to freezing in a 40°C plate freezer and is not considered a necessary step if freezing to below -20°C is accomplished immediately after compression.

6. Freeze Drying of Conditioned Compressed Bars:

Frozen bars were removed from the foil pouches, placed in drying trays and freeze-dried using radiant heat of 20°C maximum temperature. This drying required approximately 6 to 7 hours but was normally performed overnight. The low drying temperature was used to prevent the moisture mimetic agent from softening and migrating into the surrounding product.

After drying, the compressed bars were vacuum sealed in laminated foil pouches, labeled and stored at 4°C until packed for shipping.

B. Product Evaluation:

The above products were evaluated as specified under this contract as follows:

1. Composition:

a. Calculated caloric value of each product bar was approximately 125 kcal. The actual kcal per gram of material and per bar are shown in Table III. These values were found to be higher than initially calculated for most products. A reduction in caloric content by reducing fat levels would aid rehydration of these products.

b. Binders and additives were less than 25 percent by weight of all products as is shown in the formulas, (Table I).

c. All components are FDA approved for human consumption.

2. Physical Requirements:

a. All bars are rectangular and dimensionally equal with thickness and width being approximately 1.3 and 4 cm., respectively. Dimensional and weight data for these products are shown in Table V.

b. Minimum bulk density is not less than 0.8g per cc as shown in Table V. Increased density above 0.8 gm per cc greatly reduces rehydration and increases hardness of the product bar.

c. The bars remained dimensionally stable within 10 percent when held for 24 hours at 38°C under a pressure of 0.5 kg per cm^2 (25 pounds per 3.75 square inch bar). The actual dimensional change for each product is shown in Table VI. The bars were found to be very stable in regard to handling properties.

d. All bars could easily be sheared by the incisors at room temperature and subsequently masticated and swallowed without difficulty as shown in Table VI.

e. The above physical requirements were not significantly altered by storage at 38°C for three months. There was no leakage or obvious transfer of fat during this storage period in any of the products. See Table IV.

3. Chemical Evaluation:

a. The fat content of these bars accounted for less than 40% of the total caloric content of each product as shown in Table III. The highest percentage of calories supplied by fat was less than 30%.

b. There were no values for fat rancidity, browning or free fatty acids which increased more than 100% during three months storage at 38°C. These values are all well within acceptable limits and are shown in Tables III and IV. Fat rancidity was measured by Initial Peroxide Values (IPV) using the standard AOAC method of determination. Browning was measured by using the Reflectance Method. Free fatty acids (FFA) were measured by using the standard AOAC method of determination. These values are all well within normal expected values and indicate that these products can withstand the storage conditions used for this test.

c. Hydration of the compressed bars was satisfactory in that all items rehydrated to a normal moisture content within 20 minutes using techniques practicable in a canteen cup. Some products were not fully hydrated but were not objectionable for consumption. These results are shown in Tables VII, VIII and IX.

4. Sensory Evaluation:

a. All items were found acceptable initially and after three months storage at 38°C. when consumed in the dry bar state as is shown in Table VI.

b. All items received an average panel score of at least 6 on a 9-point hedonic scale initially and after three months storage of 38°C., as shown in Table VII.

These panel evaluations were performed under the supervision of a trained sensory evaluation scientist.

Discussion

It was found that sufficiently cohesive bars could be made using very low compression pressures without major fragmentation if the materials were properly conditioned and blended. It was not necessary to include binding agents to achieve cohesiveness. The major problems encountered were equalizing the caloric density while maintaining rehydratability and preventing browning during storage studies.

The problems of equal caloric density and rehydratability seemed insurmountable in that many of the high caloric materials tested would not permit rehydration after compression. When fats were used they were compressed into and around the other components, thus blocking channels for water penetration. Attempts to solve this problem by use of surface active agents, emulsifiers and saponifiers were unsuccessful. Two agents were found which did permit the incorporation of fats and not severely hinder rehydration after compression. These two agents were non-dairy creamers of the "instantized" type and the matrix B_2 developed by Pillsbury under contract for U. S. Army Natick Laboratories. It was found necessary, however, not to permit these materials to become hydrated to any measurable degree prior or during compression. If moisture were permitted to come in contact with these materials, they would lose their rehydratable characteristics. It was, therefore, necessary to condition the fragile components separate from the dry fat containing components and with moisture levels low enough to prevent migration of moisture to these components during compression.

The above methods did not solve all rehydration problems. It was found that sauces having a high sugar content were very difficult to rehydrate. Sauces that would not permit rehydration after compression when prepared and dried in conjunction with the other components of the formula were prepared and dried separately. This permitted conditioning of the other components separate from the sauce which minimized the exposure of the sauce to moisture and prevented excessive hardening of these sauces during compression. This procedure was not followed for the shrimp creole and is believed that such a procedure would aid rehydration of this product. For the preparation of chicken ala king it was even found necessary to include dry chicken meat of fine particle form in the dry sauce material to permit water penetration and rehydration of the sauce after compression. This procedure may aid rehydration of other sauces; however, no further studies were made with this technique since this was the last product to be completed. It is recommended that this procedure be followed for the barbecue pork product.

Browning presented problems. It was found that even though the moisture levels used for conditioning the bar components were low enough to maintain microbial stability, browning of major proportions did occur during 38°C. storage. This browning was unexpected and required considerable effort to resolve. The expedient of simply removing the added water by freeze-drying resulted in either very fragile or very hard products. Changes in formulation and compression techniques were required to resolve these problems. Inclusion of a moisture mimetic agent to improve acceptability in the dry state was considered necessary for most products. Initial tests indicated that these agents would also serve as a binding agent for the fragile bars and a softening agent for the hard bars. Product prepared by incorporating these agents into the conditioning water for distribution purposes lead to severe rehydration problems after freeze-dehydration. Apparently, the moisture mimetic agents (sorbitol and glycerine) migrated to the particle surfaces during freeze-dehydration even though the maximum drying temperature was maintained at 21°C. This migration apparently blocked water absorption paths and prevented rehydration of the product.

A solution to the problem of blocked rehydration was found by preparing the moisture mimetic agent into small particulate material and adding this material just prior to compression to prevent it from becoming hydrated. This apparently prevented migration and left rehydration pathways open for the water to enter. This, however, detracted from the acceptability of the bar when consumed in the dry form. It also resulted in a more fragile bar but being satisfactory in regard to handling without breaking.

TABLE I

Formulas for Compressed Food Bars

a. Beef Stew Bar:

Ingredients	%
Beef, cooked, diced 3/16"x3/4"x3", fr. dehyd.	62.8
Potatoes, diced 1/4", cooked, fr. dehyd.	13.0
Carrots, 3/8" dice, cooked, fr. dehyd.	6.5
Peas, scarified, cooked fr. dehyd.	4.6
Seasoning Mix*	8.1
Moisture mimetic agent	5.0
Total	100.0

*Seasoning Mix:

Soup and Gravy Base, beef (Griffith DB-1626)	57.0
Matrix B_2	36.0
Onions, minced, dehyd.	6.1
Pepper, white	0.9
Total	100.0

b. Chicken and Rice Bar:

Ingredients	%
Chicken, cooked, diced 3/16"x3/4"x3",fr. dehyd.	65.0
Rice, instant, cooked, fry. dehyd.	19.0
Soup and gravy base, chicken (Lipton)	6.0
Salt	1.0
Hydrolyzed vegetable protein (Nestle's Super 3H)	0.8
Monosodium glutamate	0.2
Matrix B_2	3.0
Moisture mimetic agent	5.0
Total	100.0

c. Barbeque Pork Bar:

Ingredients	%
Pork, cooked, diced 3/16"x3/4"x3", fr. dehyd.	67.0
Barbecue sauce, cooked, fr. dehyd.*	28.0
Moisture mimetic agent	5.0
Total	100.0

TABLE I (Cont'd)

Formulas for Compressed Food Bars

*Barbecue Sauce	%
Apple sauce, instant, dry	17.00
Grapefruit juice, powder	5.75
Tomato powder	34.00
Salt	5.75
Sugar	22.40
Onion, minced, dehyd.	11.00
Garlic powder	0.10
Hydrolyzed vegetable protein (Nestle's Super BE)	3.50
Pepper, black	0.25
Cloves, ground	0.10
Cinnamon, ground	0.15
Total	100.00

NOTE: The above ingredients were blended together with two parts water added to one part dry material, cooked to 85°C., spread in drying trays, frozen and freeze-dried. The dry material was chopped into a coarse powder prior to blending with the pork to form the bar.

d. Chili with Bean Bar:

Ingredients	%
Beef, cooked 3/8" ground, fr. dehyd.	57.0
Kidney beans, cooked, fr. dehyd.	23.0
Tomato powder	5.0
Chili seasoning mix*	10.0
Moisture mimetic agent	5.0
Total	100.0

*Seasoning Mix:

Soup and gravy base, beef (Griffith DB 1626)	60.00
Chili powder	35.00
Onion, minced, dehyd.	4.00
Pepper, ground, red	0.50
Garlic powder	0.25
Monosodium glutamate	0.25
Total	100.00

TABLE I (Cont'd)

Formulas for Compressed Food Bars

e. Chicken ala king bar:

Ingredients	%
Chicken, cooked, diced 3/16"x3/4"x3", fr. dehyd	65.5
Mushrooms, diced, fr. dehyd.	4.0
Red pimientos, diced, fr. dehyd.	2.0
Ala king sauce, dry*	28.5
Total	100.0

It was necessary to include freeze-dehydrated chicken fines in this sauce mix to obtain rehydration of the sauce.

f. Tuna Salad Bar:

Ingredients	%
Tuna, drained	90.0
Mayonnaise	10.0
Total	100.0

The above was blended on a wet basis and then freeze-dried.

Ingredients, Dry	%
Tuna, mayonnaise mixture, fr. dehyd.	95.0
Moisture mimetic agent	5.0
Total	100.0

g. Scrambled Egg and Bacon Bar:

Ingredients, Wet	%
Egg whites, fresh	72.0
Egg yolks, fresh	12.3
Non-fat milk solids	9.2
Bacon diced 1/4", fried	3.5
Sorbitol, 70% soln.	2.5
Salt	0.5
Total	100.0

TABLE I (Cont'd)

Formulas for Compressed Food Bars

The above ingredients were blended together, cooked in a pasteurizer using 77°C water and gently stirred until reaching 72°C temperature. At this temperature, the mix had started to coagulate but was still pourable. The cooked egg was then poured into drying trays, frozen and freeze-dried. The dried material was broken up and compressed into bars without conditioning.

h. Shrimp Creole bar:

Ingredients, Wet	%
Shrimp, cooked	48.5
Rice, instant, cooked	12.5
Seafood sauce (Hoffman House)	15.5
Catsup	18.5
Red Pimento, diced	5.0
Total	100.0

The above ingredients were blended together and freeze-dried. This dry material was used in the following formula for the compressed bars:

Shrimp & sauce mix, fr. dehyd.	95.0
Moisture mimetic agent	5.0
Total	100.0

i. Creamed Mixed Vegetable and Ham Bar:

It was necessary to include ham in this product in order to increase the caloric density and still achieve rehydration after compression.

Ingredients	%
Ham, diced 1/4", fr. dehyd.	23.4
Corn, cooked, fr. dehyd.	18.6
Peas, scarified, cooked, fr. dehyd.	16.7
Carrots, diced 3/8", cooked fr. dehy.	11.8
Non-dairy creamer (Carnation)	14.5
Matrix B_2	10.0
Moisture mimetic agent	5.0
Total	100.0

j. Apple Pie Filling Bar:

Ingredients	%
Apples, diced, dried	77.5
Non-dairy creamer (Coffee Mate)	12.5
Matrix B_2	10.0
Total	100.0

TABLE II

Conditioning of Components
Prior to Compression

Product	Component	Water Level*
Beef Stew	All components	15%
Chicken with Rice	Chicken	10%
Barbeque Pork	Pork	10%
Chili with Beans	All components	15%
Tuna Salad	All components	15%
Scrambled Egg & Bacon	None	0%
Shrimp Creole	All components	5%
Apple Pie Filling	None	0
Creamed Mixed Vegetable and Ham	Ham and Vegetables	15%

* This water level was by weight of the ingredients being conditioned

TABLE III

Initial chemical composition of compressed bars

Item	Moisture (%)	Fat (%)	IPV	FFA (%)	Browning %*	k cal/ gm	Gms/ Bar	k cal/ Bar
Beef Stew	1.0	9.1	<0.1	1.5	2.9	5.1	28	143
Chicken with Rice	0.1	8.8	<0.1	1.4	2.2	5.1	28	148
Barbecue Pork	1.0	17.1	<0.1	0.8	6.6	5.3	27	143
Chili with Beans	1.4	10.5	<0.1	4.9	9.3	5.1	30	153
Chicken ala King	1.4	9.9	<0.1	3.4	4.0	5.3	28	148
Shrimp Creole	2.1	4.7	<0.1	1.7	4.0	4.6	28	129
Scrambled Egg	0.2	15.7	<0.1	1.3	3.7	5.5	28	154
Tuna Salad	1.0	7.3	<0.1	1.3	2.9	5.4	28	149
Mixed Vegetables with Ham	5.9	9.7	<0.1	2.7	4.7	4.8	28	134
Apple Pie Filling	1.6	4.9	<0.1	1.3	2.8	4.2	30	126

* By percent reflectance

TABLE IV

Chemical Composition of Compressed Bars at 0 and 3 Months Storage at 38°C

Item	IPV		FFA (%)		Browning (%)*	
	0 Mo.	3 Mo.	0 Mo.	3 Mo.	0 Mo.	3 Mo.
Beef Stew	<0.1	<0.1	1.5	4.0	2.9	4.0
Chicken with Rice	<0.1	<0.1	1.4	2.8	2.2	2.8
Barbecue Pork	<0.1	<0.1	0.8	1.6	6.6	10.6
Chili with Beans	<0.1	0.5	4.9	1.6	9.3	12.4
Chicken ala king	<0.1	<0.1	3.4	2.9	4.0	2.8
Shrimp Creole	<0.1	0.4	1.7	2.2	4.0	6.3
Scrambled Egg	<0.1	<0.1	1.3	1.3	3.7	4.0
Tuna Salad	<0.1	1.0	1.3	2.1	2.9	3.5
Mixed Vegetables with Ham	<0.1	<0.1	2.7	4.0	4.7	8.9
Apple Pie Filling	<0.1	<0.1	1.3	2.0	2.8	3.7

* By percent reflectance

TABLE V

Results of Physical Testing of Compressed Bars

	Dimensions (cm) (L x W x Th.)	Wt. (gms)	Drop Test(1)	Compression Test(2) %	Density (gms/cc)
Beef Stew	6.5 x 4 x 1.35	28.5	0/0	3	.81
Chicken with Rice	6.5 x 4 x 1.35	28.0	1/0	0	.80
Barbecue Pork	6.5 x 4 x 1.30	27.1	0/0	3	.80
Chili with Beans	6.5 x 4 x 1.40	29.8	0/0	0-3	.80
Chicken ala King	6.5 x 4 x 1.35	28.2	1/0	0	.80
Shrimp Creole	6.5 x 4 x 1.35	27.9	1/0	0	.80
Scrambled Eggs	6.5 x 4 x 1.30	27.8	3/0	0	.82
Tuna Salad	6.5 x 4 x 1.35	27.8	0/0	0	.79
Mixed Veg. with Ham	6.5 x 4 x 1.35	27.7	0/0	0	.79
Apple Pie Filling	6.5 x 4 x 1.40	30.2	1/0	6	.81

(1)Number breaks without pouch./ Number of breaks when in pouch.

(2)Percentage thickness change under 0.5 grams/cm^2 for 24 hours at 38°C.

TABLE VI

Panel Acceptance Evaluation - Dry Bars
Before and After 3 Months Storage at 38°C.

Item	Panel Scores		Comments	
	Initial (Range)	3 Mos. Storage (Range)	Initial	3 Mos. Storage
Beef Stew	6.2 (4-8)	6.5 (4-8)	Good - Acceptance	Good flavor Mouthful O.K.
Chicken with Rice	6.0 (4-7)	6.2 (4-8)	Acceptable Good Chewability	Good flavor Fair mouthful
Barbecue Pork	7.4 (4-9)	7.0 (4-8)	Good - Acceptable	Good flavor Good mouthful
Chili with Beans	6.6 (4-8)	6.5 (4-8)	Good - Acceptable	Good Chili flavor Good mouthful
Chicken ala King	6.0 (4-8)	6.1 (4-8)	Good - Acceptable	Good flavor Good mouthful
Shrimp Creole	7.0 (4-8)	6.9 (4-8)	Good chewability	Excellent flavor Good mouthful
Scrambled Eggs	6.4 (4-8)	6.6 (4-8)	Acceptable - Good	Good flavor Dry-acceptable mouthful
Tuna Salad	7.2 (4-8)	7.4 (4-8)	Acceptable - Easy to chew	Good flavor Initial dry - acceptable mouthful
Mixed Vegetables with Ham	6.7 (4-8)	6.2 (4-8)	Good - Acceptable	Good flavor-Hard to hydrate in mouth
Apple Pie Filling	6.8 (4-9)	6.6 (4-8)	Characteristics in Excellent eating	Excellent flavor and mouthful

TABLE VII

Panel Acceptance Evaluation
Rehydrated Bars before and after three month storage at 38°C.

Item	Panel Score Initial (Range)	Panel Score 3 Mo Storage (Range)	Comments Initial	Comments 3 Months Storage
Beef Stew	7.2 (5-9)	7.2 (4-9)	Good stew flavor Lacks beef flavor Good Texture	Good flavor Good mouthful
Chicken with Rice	7.3(5-9)	7.2 (4-8)	Good chewability Good hydration Good flavor	Good flavor Good to dry mouthful
Barbecue Pork	7.0 (5-9)	6.6 (4-8)	Good barbecue Good texture Sauce too thin	Good BBQ-Lacks pork flavor. Sauce not fully hydrated
Chili with beans	7.1 (5-9)	7.2 (4-9)	Good flavor, Meat rubbery	Good to mild chili fl., Good mouthful
Chicken ala King	7.5 (6-9)	6.8 (5-8)	Good flavor, Too spicy, Good Texture	Good flavor Good mouthful
Shrimp Creole	7.0 (4-9)	7.4 (5-9)	Good flavor, Good texture, Sauce too thin	Good flavor Good chewability
Scrambled Eggs	7.2 (5-9)	6.8 (4-9)	Weak egg flavor Acceptable texture	Good flavor, Good mouth feel, Some rubbery texture
Tuna Salad	7.0 (5-8)	7.2 (4-9)	Mild flavor, Good hydration, Soft texture	Good flavor-needs salt, Good to soft mouthful
Mixed Veg. with Ham	7.4 (4-9)	6.2 (4-8)	Good veg. flavor Sauce too thin Good texture	Good flavor Not fully hydrated
Apple Pie Filling	7.4(5-9)	6.9 (4-9)	Good apple flavor Good texture, Lacks apple pie seasoning	Good flavor Not fully hydrated

TABLE VIII

Rehydration of Compressed Bars - Initial

Item	Com-pressed	Oz. Water	Temp. of Water	Time (Min)	Comments
Beef Stew	Yes	4	70°C	20	Good rehy. and consistency
	No	4	70°C	20	" " " "
Chicken with Rice	Yes	4	70°C	20	Good rehy. and consistency. Some free water
	No	4	70°C	20	Good rehy. and consistency.
Barbecue Pork	Yes	3	70°C	20	Fair rehy. Some pieces not fully rehydrated
	No	3	70°C	20	Good rehydration
Chili with Beans	Yes	3	70°C	20	Good rehy. and consistency
	No	3	70°C	20	" " " "
Chicken ala King	Yes	4	70°C	20	Good rehy. and consistency
	No	4	70°C	20	" " " "
Shrimp Creole	Yes	3	70°C	20	Good rehy. and consistency
	No	3	70°C	20	" " " "
Scrambled Egg	Yes	2½	100°C	20	Must crush and drop into boiling water while stirring.
	No	2½	100°C	20	Good consisten./Drop into water while stirring.
Tuna Salad	Yes	3½	20°C	20	Good rehy. Slightly mushy
	No	3½	20°C	20	" " " "
Mixed Veg. & Ham	Yes	3	70°C	20	Some Veg. Not fully rehy.
	No	3	70°C	20	Good rehy.
Apple Pie filling	Yes	3	70°C	20	Some pieces not fully rehy.
	No	3	70°C	20	Good rehydration

TABLE IX

Rehydration of Compressed Bars after 3 Months Storage at 38°C

Item	Water Oz.	Temp Water	Time (Min)	Comments
Beef Stew	4	70°C.	20	Good hydration
Chicken with Rice	3-3/4	70°C.	20	Good hydration
Barbecue Pork	3-1/2	70°C.	20	Sauce not fully hydrated
Chili with Beans	4	70°C.	20	Good hydration
Chicken ala King	4	70°C.	20	Good hydration
Shrimp Creole	3-1/2	70°C.	20	Sauce slow to hydrate
Scrambled Egg	2-1/2	100°C.	20	Good hydration Must break up into boiling water
Tuna Salad	3-1/2	20°C.	20	Excellent hydration
Mixed Vegetables with Ham	3-1/2	70°C.	20	Slow to hydrate - hard to break up with spoon
Apple Pie Filling	3-1/2	70°C.	20	Poor hydration hard to break bar

SUMMARY

Ten food items have been developed, prepared and evaluated under Phase I of this contract. Two hundred and fifty bars of each of the ten itmes have been prepared.

Fragmentation of meat and vegetable bars was prevented by conditioning with approximately 10% water. In most cases, conditioning of meats and vegetables had to be performed separately from the other ingredients to permit rehydration of the compressed material. Moisture available to the sauces caused hardening to the extent that rehydration was very difficult, if not impossible.

Browning which occurred during storage at 38°C in products containing approximately 10% moisture was eliminated by freeze-drying the compressed bars. Fragility and dry eating characteristics were improved by the addition of discrete particles of a moisture mimetic agent consisting of six parts sorbitol and one part glycerol. Addition of these materials separately or with water resulted in very poor rehydration.

The ten prescribed species of compressed bars were found to meet all physical, chemical and rehydration characteristics, as well as panel ratings for consumption before and after hydration. It was found necessary, however, to break most of these bars into quarters prior to placing them in the water for rehydration.

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13. ABSTRACT

Dried foods, plasticized to prevent fragmentation, were compressed with appropriate binders into bars of approximately equal size, density and caloric content (140 ± 14 kcal/bar). Bars representing the following food items were designed, formulated, fabricated and evaluated for physical, chemical and sensory characteristics after storage for 3 months at 38°C: (1) beef stew, (2) chicken and rice, (3) barbecue pork, (4) chili with beans, (5) shrimp creole, (6) chicken a la king, (7) tuna salad, (8) scrambled eggs with bacon, (9) mixed creamed vegetables and (10) apple pie filling. Complete information on all formulations and processing is supplied.

In accordance with design requirements bars were rated by a taste panel as acceptable for consumption from the dry-compressed state and for consumption after rehydration for 20 minutes in water at 80°C (25°C for items consumed at room temperature). Bars were evaluated for cohesiveness, dimensional stability under pressure, ease of shear by the incisors and subsequent mastication. Observations on free fatty acids, peroxide value and browning (reflectance units) are recorded for each bar at the time of fabrication and after the referenced storage.

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