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TECHNICAL REPORT
70-67-FL

FABRICATION OF FOOD BARS BASED ON COMPRESSION AND MOLDING MATRICES

by
Robert L. Pavey

Swift & Company
Research and Development Center
Oak Brook, Illinois 60521

Contract No. DAAG 17-67-C-0068

June 1970

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 II 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 Dr. R. L. Pavey. He was assisted by Dr. E. E. Rice, 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.

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ABSTRACT

Dried foods, some plasticized to prevent fragmentation, were compressed with appropriate binders into bars of approximately equal size, density and caloric content (148 ± 25 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) Citrus Fruit Drink (2) Hot Chocolate Beverage (3) Cream of Mushroom Soup (4) German Potato Salad (5) Cole Slaw (6) Pineapple-Cottage Cheese Salad (7) Welsh Rarebit (8) Crab Meat Cocktail (9) Chocolate Pudding (10) Pineapple Fruit Pudding. 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 70°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 (fluorescence units) are recorded for each bar at the time of fabrication and after the referenced storage.

Introduction

The purpose of Phase II 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. Citrus Fruit Drink
b. Hot Chocolate Beverage
c. Cream of Mushroom Soup
d. German Potato Salad
e. Cole Slaw
f. Pineapple-Cottage Cheese Salad
g. Welsh Rarebit
h. Crab Meat Cocktail
i. Chocolate Pudding
j. Pineapple Fruit Pudding

Design Parameters for Compressed Bars

A. Composition

1. Primary ingredients normal to each food item.

2. Bars to contain approximately 125 kcal.

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 0.8 g 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% 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% 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 and Results

A. Product Preparation

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

1. Component Preparation

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

a. 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% yield resulting in crisp dices but having no burnt particles.

b. Cabbage, Shredded, Glycerine Treated, Freeze-Dried

Green head cabbage was washed, outer leaves removed, cut into quarters, cored and then shredded in a Hobart Food Chopper. The chopped cabbage was then soaked for one hour in 2 parts water solution containing 1/2% glycerine (99% CP Grade). After draining, 2000 ppm sodium meta bisulfite based on cabbage was dissolved in aqueous suspension containing 1% by weight of cabbage. This treated cabbage was then placed in drying trays and frozen in a -40°C. plate freezer for one hour or longer prior to freeze-drying.

c. Crab Meat, Glycerine Treated, Freeze-Dried

Canned frozen Alaska King Crab meat was thawed, drained, examined for removal of claws and shell material and then soaked in a 10% glycerine water solution for one hour. After draining, the product was placed in drying trays and frozen in a -40°C. plate freezer prior to freeze-drying.

d. Mayonnaise, Freeze-Dried

Mayonnaise was spread in drying trays and frozen in a -40°C. plate freezer overnight prior to freeze-drying.

e. Moisture Mimetic 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 coarse 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.

f. Mushrooms, Diced, Freeze-Dried

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

g. Onions, Minced, Cooked, Freeze-Dried

White onions were peeled, washed, cored and then chopped in a Hobart Food Chopper prior to freezing in a -40°C. plate freezer for freeze-drying.

h. Onions, Chopped, Glycerine Treated, Freeze-Dried

White onions were peeled, washed, cored and chopped as before. The chopped onions were then soaked in a 1/2% glycerine water solution for one hour and drained prior to freezing in a -40°C. plate freezer prior to freeze-drying.

i. Peppers, Green, Chopped, Glycerine Treated, Freeze-Dried

Green peppers were cut open, seeds removed, washed and chopped in a Hobart Food Chopper. The chopped peppers were then soaked in a 1/2% glycerine water solution for one hour, drained and frozen in a -40°C. plate freezer prior to freeze-drying.

j. Pineapple, Crushed, Glycerine Treated, Freeze-Dried

Crushed, canned, water pack pineapple was drained and then soaked in a 10% glycerine water solution for one hour. After draining, the product was frozen in a -40°C. plate freezer prior to freeze-drying.

k. Potatoes, Diced, Freeze-Dried

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.

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; as stated above for the product formulas. They were then placed in drying trays and frozen in a plate freezer. The frozen products were freeze-dried using radiant heat of 25°C. maximum temperature. The products were dried until coming to 25°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. A maximum temperature of 25°C. was necessary to prevent loss of glycerine during drying.

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. The formulas required no preparation other than blending together and in some cases heating of the material prior to compression. Those requiring heating to aid cohession during compression were citrus fruit drink, hot chocolate beverage and chocolate pudding, all of which were heated to 50°C.

a. Citrus Fruit Drink (Orange Drink)

The orange drink formula resulted from studies evaluating various orange juice concentrates: Sunkist, Perma, Stahely Flavors, Atom Orange No. 251, McKee Orange Crystals, Orange Juice Pulp, Tang, Start, Orange Peel Granules, various sugars such as sucrose, lactose, dextrose, corn syrup

solids, and various starches such as Col-Flo No. 67, Solu-Pro (Wilson), sodium carboxymethylcellulose, Mor-Rex, and Instant Clear-Gel. The best flavor, rehydration, bar formulation and stability was achieved by using the formula shown in Table I.

The orange drink formula was compressed into 40 gram bars after heating the formula to 50°C. prior to compression. Compression was at approximately 800 psi product pressure. Rehydration of the Orange Drink Bar required 7 ounces of cold (20°C.) tap water and that the bar be crushed by hand prior to adding the water.

b. Hot Chocolate Beverage

The hot chocolate beverage formula resulted from studies evaluating the various chocolate ingredients such as Hershey Instant Chocolate, Great Shakes formula, Chocolate Sauce, Dragoco Cocoa No. 2424, Fermenich Imitation Fudge Flavor, and Quick, various carbohydrates such as sucrose, dextrose, corn syrup solids, and various starches such as Instant Plus, Vel-Tol, and matrix B2. The final formula provided best flavor, rehydration and stability.

The hot chocolate beverage formula was compressed into 38 gram bars after heating the formula to 50°C. prior to compression at approximately 600 psi product pressure. Six ounces of hot (70°C.) water was used for rehydration of the bar after crushing by hand prior to adding to the hot water.

c. Cream of Mushroom Soup

The cream of mushroom soup formula resulted from studies evaluating various commercially available mushroom soups which we freeze-dried and compressed, all of which were unsatisfactory. Also evaluated were various flavoring agents such as chicken stock, onion powder, monosodium glutamate, and mushroom powder plus various thickening agents such as carboxymethycellulose, dry milk solids, pregelatinized starches, carrageenan and non-fat dry milk.

Bars weighing 28 grams were formed from the formula using 500 psi product pressure. The bars were rehydrated in 5.5 ounces hot (70°C.) water after breaking into 8 pieces. Sufficient saltiness resulted from the use of the Instant Broth (Herb Ox) and cracker meal.

d. German Potato Salad

The German potato salad formula resulted from studies evaluating various forms of dried potatoes, the use of glycerin and sorbitol, pregelatinized cornmeal, and vinegar.

Bars were formed using 30 grams of the above formula and 400 psi product pressure. The bars were broken into 4 to 8 pieces prior to adding to 3 ounces of 70°C. water for rehydration.

e. Cole Slaw

Many cole slaw products investigated and placed in 38°C. storage did not hold up due to severe browning. Extensive evaluations of glycerine levels showed that glycerine did have a great effect on browning. Attempts to incorporate glycerol triacetate were unsuccessful in that this compound is not readily soluble in water and, therefore, did not distribute throughout the suspension of cabbage. The use of sodium meta bisulfite at levels up to 2000 ppm of dry cabbage did not appear to be effective in reducing the browning. Other additions studied have been malic acid, citric acid, ascorbic acid, iodo acetic acid, sodium tetrathionate, L-cystine, hydrogen peroxide and ammonium persulfate. None of these were effective in reducing the degree of browning and, in some cases such as malic and acetic acids, actually induced more severe browning.

Sauce components were also evaluated independently and in various combinations as to their affect on browning of the cabbage. In addition, various alternative components such as lactose and various substitutes for the synthetic dry

vinegar (Vinstant) were evaluated. The only components found to contribute toward browning were acetic acid and the chopped English Walnuts. Nuts were added to increase the caloric value of this product. Almonds were then evaluated and found not to show evidence of browning. The affect of walnuts may have been expression of oil out of the nut meats rather than actual browning.

Additional efforts with cabbage treatment showed that washing the shredded cabbage in five parts water did reduce the degree of browning. It was also found that elimination of glycerol treatment also reduced the browning. However, when rehydrated after compression, the cabbage was very mushy with no fibrous texture at all. It was found that by soaking the cabbage in a 1/2% glycerine solution for one hour did result in cabbage having sufficient particle size when rehydrated after compression and also minimized the degree of browning. Sodium meta bisulfite was also used at a level of 2000 ppm of dry cabbage even though it has not been demonstrated in our studies to be effective.

In preparing samples for storage evaluation the cabbage, green peppers and onions were shredded, washed in five parts water for one hour with occasional stirring, drained, soaked in a 1/2% glycerine solution for one hour, drained, sodium meta bisulfite added in solution and well mixed, then freeze-dried at a maximum shelf temperature of 25°C.

This dry mixture was mixed with the dry sauce components shown in the formula. It was found that it was not necessary to compress a laminated bar with this formula to obtain satisfactory rehydration since the bars could easily be broken into small pieces without adversely affecting particle size of the cabbage. Bars were compressed using 30 grams of the formula and compression of 500 psi product pressure. The bars were rehydrated using 4 ounces of cold (20°C.) tap water after breaking into small pieces by hand.

f. Pineapple-Cottage Cheese Salad

The pineapple cottage cheese salad formula resulted from studies to evaluate various sources of pineapple such as Dole and Bix, and the use of natural cottage cheese with water prior to compression.

Bars were compressed from 30 grams of the formula using approximately 500 psi product pressure. Rehydration was accomplished by breaking the bars into 4 ounces of cold (20°C.) tap water.

g. Welsh Rarebit

The Welsh Rarebit formula was very difficult to develop in regard to flavor for dry and rehydrated comsumption and also in regard to rehydration. Various fillers were evaluated in attempts to aid the dry flavor and also aid rehydration. The fillers evaluated were bread crumbs, croutons, matzo meal, crackers and cracker meal, Waverly wafers, corn flakes, and melba toast. Flavoring variables included studying uses of Cheese Tang, salt, dry aged Cheddar cheese mix, Holland Reisk, in addition to those used in the final formula. Other variables studied were the use of glycerin, sorbitol, non-dairy creamers and carrageenin as binders.

This formula was compressed into 33 gram bars using approximately 600 psi product pressure. Rehydration was accomplished by crushing the bar by hand and placing in 4.5 ounces of hot (70°C.) water.

h. Crab Meat Cocktail

Development of a crab meat cocktail entailed treatment of the crab meat and developing a sauce which would rehydrate after compression and incubated storage. It was well known that the freeze-dried crab meat would fragment during compression unless conditioned properly. Due to results with cole slaw it was decided to evaluate conditioning by treating the meat with glycerine. Solutions containing 5, 10, 15 and 20% glycerine were used for soaking canned crab meat for one hour, drained and freeze-dried.

Freeze-dried crab meat of various glycerine treated levels were combined with various levels of dry sauce until the desired flavor was achieved. This was found to be 75% crab meat and 25% sauce. However, this level of sauce was found to harden during 38°C. storage resulting in poor rehydration. Reducing the sauce to 20% and adding 2% synthetic dry vinegar to adjust the flavor was found acceptable.

Studies of the various glycerine levels showed 10, 15 and 20% glycerine treated crab meat to be very spongy when compressed and that the glycerine caused the dry sauce to harden. The 5% glycerine level also hardened to some extent while no glycerine fragmented badly. Further studies showed that approximately a 4% glycerine level would be best. This was accomplished by combining crab meat without glycerine and crab meat containing 10% glycerine in various ratios. From these studies the final formula was used in preparing samples for submission under this contract.

This formula was compressed into 31 gram bars using approximately 600 psi product pressure. Rehydration was accomplished by placing the bar in 4 ounces of cold (20°C.) tap water.

i. Chocolate Pudding

The chocolate pudding formula resulted from modification of the hot chocolate beverage reported in b. above. Modifications in levels and use of pregelatinized starch resulted in a very good pudding that rehydrated in hot water and after cooling had a very good pudding texture.

The formula was heated to 50°C. prior to compression into 38 gram bars. The bar was crushed by hand prior to adding to 4 ounces of hot (70°C.) water for rehydration. Cooling of the pudding at room temperature for 20 minutes was sufficient for the pudding to set. However, a better consistency resulted when the product was chilled in a refrigerator.

j. Peaches or Strawberries and Cream (substituting Pineapple Fruit Pudding)

Extensive effort to rehydrate compressed, dried peaches or strawberries was unsucessful as with the fruit cocktail. Approval to substitute a pudding was granted. The pineapple fruit pudding was developed from modification studies of the chocolate pudding formula. The use of glycerine treated pineapple was found to greatly improve acceptability of the product both in the dry and the rehydrated state.

Pineapple fruit pudding bars were formed by compressing 38 grams at approximately 600 psi product pressure. Rehydration was accomplished by crushing the bar by hand and placing in 3.5 ounces of hot (70°C.) water and chilled at room temperature for 20 minutes.

4. Compression of Food Bars

A compression die and punch assembly was constructed having dimension of 4 cm x 6.5 cm x 22 cm high internally. The product contact surfaces of the base plate and piston of this die was Teflon coated to prevent product sticking. 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, excessive compression was avoided.

Relaxation of the bars after compression was prevented by immediately vacuum sealing them in pouches. Components of products were blended in a Hobart mixer. The moisture mimetic agent, where used, was blended with the other components just prior to weighing and compressing the bars. Products requiring heat prior to compression to achieve proper cohesion without excess compression were placed in a closed container and heated to 50°C. in a 55°C. oven.

Compression was performed on an air-operated hydraulic bench press. Pressures required for product compression were from 500 to 800 psi product pressure. Dwell

time was approximately 5 seconds for all products. After compression, products were vacuum sealed in laminated pouches, labeled and held until packed and shipped.

B. Product Evaluation

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

1. Composition

a. Calculated caloric value of each food bar was in excess of 125 kcal. The actual kcal per gram of product and per food bar are shown in Table II. These values range from 123 kcal to 173 kcal per bar with the average being 148 kcal per bar. These values are found to be higher than initially calculated for many of these items. A reduction in caloric content for items having high caloric values would require lighter weight bars of smaller dimension or addition of non-nutriative fillers.

b. Binders and additives are less than 25% by weight for all products as is shown in the formulas (Table I). Very little of the ingredients are added for binding purposes.

c. All components used 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 IV.

b. Minimum bulk density is not less than 0.8 g per cc as shown in Table IV. Actually many of these items have a bulk density of 1.0 or higher. This was necessary to achieve proper cohesion of the bar having equal physical dimensions. This did not impede rehydration since the bars were easily crushed by hand which permitted rapid rehydration.

c. The bars remained dimensionally stable within 10% when held for 24 hours at 38°C. under a pressure of 0.5 kg per cm^2. The actual dimensional change for each product is shown in Table IV. 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 V.

e. The above physical requirements were not significantly altered by storage at 38°C. for 3 months. There was no leakage or obvious transfer of fat during this storage period in any of the products.

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 II. The highest percentage of calories supplied by fat was less than 29.6%.

b. There were no values for fat rancidity, browning or free fatty acids which increased more than 100% during 3 months storage at 38°C. These values are all well within acceptable limits and are shown in Tables II and III. Fat rancidity was measured by Initial Peroxide Values (IPV) on chloroform extracted fat using the standard AOAC method of determination for fats and oils #CD8-58. Browning was measured by using the spectrophotometric fluorescence method using quinine sulfate as a reference solution in a Beckman DK-2A spectrophotometer with a fluorescence attachment. Free fatty acids (FFA) were measured on chloroform extracted fat by using the standard AOAC method of determination for fats and oils #CA5A-40. These values are all well within normal expected values and indicate that these products can withstand the storage conditions used for this test. Water (A_W) was determined as a percent equilibrium relative humidity (NLABS Tech. Rep.FD-19). Moisture was determined using a 70°C. vacuum oven for 16 hours. Fat was determined by ether extraction.

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 VI and VII. All products were crushed or broken into small pieces prior to the addition of water.

4. Sensory Evaluation

a. All items were found acceptable initially and after 3 months storage at 38°C. when consumed in the dry bar state as is shown in Table V.

b. All items received an average panel score of at least 6 on a 9-point hedonic scale initially and after 3 months storage at 38°C., as shown in Table VI.

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 relatively low (500 to 800 psi) product compression pressures without major fragmentation of the products if properly conditioned prior to compression. The conditioning of products used during Phase II of this contract differed from that of Phase I where water was used as the conditioning agent. The use of water required re-drying of the compressed bar to prevent excess hardening, collapse of the product and chemical deterioration. In this phase it was found that conditioning could be accomplished by the use of glycerine infusion into components for certain products and by heating of the components prior to compression for others.

Glycerine infusion was accomplished by soaking the fragile components of the formulas in water solutions containing various levels of glycerine. Optimum levels of glycerine were determined to prevent fragmentation of these materials when compressed after freeze-drying without creating conditions leading to poor rehydration or excess hardening due to bar collapse after compression. The use of glycerine as a conditioning agent eliminated the need to re-dry the bars after compression, increased the caloric density of the products, and improved their acceptability when consumed in the dry state due to the moisture mimetic properties of the glycerine.

Heating of other formulas increased the cohesion of material such as sugars and starches. This was necessary to achieve proper cohesion of certain products without excess pressures of compression or excessively high density of product, both of which create excessively hard products.

Achieving equal caloric density, proper rehydratability and cohesiveness to withstand handling were interrelated development problems. Proper cohesion to withstand requirements while maintaining rehydratability were achieved at the sacrifice of equal caloric density. This resulted in higher caloric values than required which could only be resolved by incorporation of non-nutriative components, considered to be more objectionable than the high caloric values.

Even with the use of glycerine as a conditioning agent, it was found impossible to compress fruits and achieve proper rehydration in the 20 minute specified time. Excellent products could be produced for direct consumption but required 2 to 3 times longer for proper rehydration.

Higher levels of glycerine treatment of the cabbage for the cole slaw product lead to excessive browning in the cabbage. This was minimized by lowering the level of glycerine infused into the cabbage. No browning inhibitors were found effective in sufficiently reducing browning in this product when higher glycerine levels were used.

The moisture mimetic agent used in these products was that developed and reported under Phase I of this contract.

TABLE I

Formulas for Compressed Food Bars

A. Citrus Fruit Drink (Orange)

Ingredients	Quantity (%)
Tang (General Foods)	60.0
Orange Start (Carnation)	15.0
Pre-Gelatinized Starch (Instant Clear-Gel)	7.5
Carbohydrate (Mor Rex)	7.5
Moisture Mimetic	7.5
Orange Peel Granules, dry	2.5
	100.0

B. Hot Chocolate Beverage

Ingredients	Quantity (%)
Sugar (Sucrose)	48.7
Cocoa, 22-24% butterfat	18.4
Whole Milk Solids	10.5
Non-Dairy Creamer (Carnation)	10.5
Moisture Mimetic	7.9
Carbohydrate (Mor Rex)	4.0
	100.0

C. Cream of Mushroom Soup

Ingredients	Quantity (%)
Non-Dairy Creamer (Carnation)	33.0
Carbohydrate (Mor Rex)	21.4
Mushrooms, chopped, freeze-dried	19.7
Pre-Gelatinized Starch (Instant Plus)	11.6
Instant Broth (Herb Ox)	8.9
Cracker Meal	5.4
	100.0

D. German Potato Salad

Ingredients	Quantity (%)
Potatoes, diced, cooked, freeze-dried	42.1
Bacon, fried, diced	20.0
Onions, minced, cooked, dried	11.7
Mayonnaise, freeze-dried	11.7
Non-Dairy Creamer (Carnation)	6.7
Salt	3.3
Synthetic Vinegar, dry (Vinstant)	2.5
Sugar (Sucrose)	1.7
Pepper, white, ground	0.3
	100.0

E. Cole Slaw

Ingredients	Quantity (%)
Cabbage, shredded, glycerine treated, freeze-dried	25.0
Green Pepper, chopped, glycerine treated, freeze-dried	6.2
Onion, chopped, glycerine treated, freeze-dried	2.1
Sugar (Sucrose)	3.3
Chopped Almonds	16.7
Non-Dairy Creamer (Carnation)	16.7
Mayonnaise, freeze-dried	27.8
Synthetic Vinegar, dry (Vinstant)	2.2
	100.0

F. Pineapple-Cottage Cheese Salad

Ingredients	Quantity (%)
Cottage Cheese, freeze-dried	63.3
Crushed Pineapple, glycerine treated, freeze-dried	15.0
Pineapple crystals (McKee)	5.0
Non-Dairy Creamer (Carnation)	16.7
	100.0

G. Welsh Rarebit

Ingredients	Quantity (%)
Cheese Sauce Base (Hellers)	70.2
Dry Cheddar Cheese (La Chedda)	18.3
Swiss Cheese Flavor (Swiss Rex)	4.2
Carboxymethylcellulose	3.1
Synthetic Vinegar, dry (Vinstant)	2.1
Mustard, dry powder	1.7
Cheddar Cheese Flavoring (Chedda Rex)	0.4
	100.0

H. Crab Meat Cocktail

Ingredients	Quantity (%)
Crab Meat, no glycerine, freeze-dried	42.0
Crab Meat, 10% glycerine, freeze-dried	38.4
Sauce, freeze-dried *	18.0
Synthetic Vinegar, dry (Vinstant)	1.6
	100.0
* Sauce, wet basis	
Seafood Sauce (Hoffman House)	12.63
Catsup, tomato	18.50
Onion, diced	43.50
Horseradish	18.50
Citric Acid	3.125
Ascorbic Acid	3.120
Oleoresin Paprika (100,000 units)	0.625
	100.000

I. Chocolate Pudding

Ingredients	Quantity (%)
Sugar (Sucrose)	40.2
Pre-Gelatinized Starch (Instant Plus)	21.7
Cocoa, 22-24% butterfat	16.4
Non-Dairy Creamer (Carnation)	8.7
Whole Milk Solids	6.5
Moisture Mimetic	6.5
	100.0

J. Pineapple Fruit Pudding

Ingredients	Quantity (%)
Sugar (Sucrose)	26.3
Pre-Gelatinized Starch (Instant Plus)	19.8
Pineapple Juice Crystals (McKee)	18.4
Non-Dairy Creamer (Carnation)	17.1
Crushed Pineapple, glycerine treated, freeze-dried	10.5
Non-Fat Milk Solids	7.9
	100.0

TABLE II

Initial Chemical Composition of Compresssed Bars

Item	Moisture %	A_w	Fat %	IPV of Fat	FFA %*	Browning %**	kcal/ gm	gms/ Bar	kcal/ Bar
Orange Drink	1.6	.28	4.7	0.1	41.7***	1.5	3.83	40	153.
Hot Chocolate	1.7	.23	6.9	0.1	2.4	4.4	4.56	38	173.
Cream of Mushroom Soup	2.8	.21	5.0	8.4	6.0	3.5	4.50	33	136.
Potato Salad	2.7	.15	18.0	0.1	2.7	2.2	4.87	30	144.
Cole Slaw	2.1	.09	29.6	0.1	2.1	2.5	3.92	30	123.
Pineapple-Cottage Cheese	0.4	.05	16.3	0.1	0.4	1.9	5.66	30	169.
Welsh Rarebit	4.1	.31	15.2	3.6	13.4***	3.2	4.56	28	128.
Crab Meat Cocktail	1.7	.07	7.4	0.1	14.0***	2.6	4.72	31	146.
Chocolate Pudding	2.9	.28	6.0	0.1	2.9	2.4	4.44	38	169.
Pineapple Pudding	2.0	.14	1.3	0.1	0.1	1.1	4.24	38	161.

* Percent of Fat
** Percent Fluorescence
*** Typical values for fats found in these products.

TABLE III

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

Item	IPV (of Fat)		FFA (% of Fat)		Browning (% Fluorescense)	
	0 Mo.	3 Mo.	0 Mo.	3 Mo.	0 Mo.	3 Mo.
Orange Drink	0.1	0.1	41.7**	43.2	1.5	2.2
Hot Chocolate	0.1	0.1	2.4	3.6	4.4	6.2
Cream of Mushroom Soup	8.4	14.2*	6.0	8.7	3.5	6.1
German Potato Salad	0.1	0.1	2.7	3.2	2.2	3.7
Cole Slaw	0.1	0.1	2.1	2.6	2.5	4.8
Pineapple-Cottage Cheese Salad	0.1	0.1	0.4	1.0	1.9	2.9
Welsh Rarebit	0.1	0.1	13.4**	14.6	3.2	5.2
Crab Meat Cocktail	3.6	6.1	14.0**	17.2	2.6	5.0
Chocolate Pudding	0.1	0.1	2.9	4.1	2.4	3.6
Pineapple Pudding	0.1	0.1	0.1	1.0	1.1	2.0

* Vacuum was lost in pouches for this product during storage.

** Typical values for fats found in these products.

TABLE IV

Results of Physical Testing of Compressed Bars

Item	Dimension (Cm) (L x W x Th)	Wt. (gms)	Drop Test*	Compression Test**	Density (gms/cc)
Orange Drink	6.5 x 4 x 1.35	40	2/0	0	1.14
Hot Chocolate	6.5 x 4 x 1.35	38	1/0	0	1.09
Cream of Mushroom Soup	6.5 x 4 x 1.35	33	0/0	0	.94
Potato Salad	6.5 x 4 x 1.35	30	2/0	0-3	.86
Cole Slaw	6.5 x 4 x 1.35	30	0/0	3-6	.86
Pineapple-Cottage Cheese	6.5 x 4 x 1.35	30	0/0	0-3	.86
Welsh Rarebit	6.5 x 4 x 1.35	28	0/0	0-3	.80
Crab Meat Cocktail	6.5 x 4 x 1.35	31	0/0	0-3	.89
Chocolate Pudding	6.5 x 4 x 1.35	38	2/0	0	1.09
Pineapple Pudding	6.5 x 4 x 1.35	38	1/0	0	1.09

* Number of breaks without pouch/number of breaks in pouch.

** Percentage thickness change under 0.5 gm/cm 2 for 24 hours at 38°C.

TABLE V

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

Item	Panel Scores $\bar{x}$ (Range) Initial	Panel Scores $\bar{x}$ (Range) 3 Months	Comments Initial	Comments 3 Months
Orange Drink	7.4 (6-9)	7.3 (6-9)	Good flavor, good mouthfeel.	Good flavor, good mouthfeel.
Hot Chocolate	7.3 (5-8)	7.6 (5-9)	Good flavor, good mouthfeel.	Good flavor, good mouthfeel.
Cream of Mushroom Soup	6.6 (5-8)	6.6 (5-8)	Good flavor, good mouthfeel.	Good flavor, good mouthfeel.
Potato Salad	7.6 (6-9)	7.7 (6-9)	Tangy flavor, good mouthfeel.	Tangy flavor, good mouthfeel.
Cole Slaw	7.0 (5-9)	6.7 (5-8)	Good flavor, good mouthfeel.	Good flavor, good mouthfeel.
Pineapple-Cottage Cheese	7.4 (6-9)	7.0 (5-9)	Good flavor, soft mouthfeel.	Good flavor, soft mouthfeel.
Welsh Rarebit	6.6 (5-8)	6.4 (5-8)	Tangy flavor, slight gummy mouthfeel.	Tangy flavor, slight gummy mouthfeel.
Crab Meat Cocktail	7.1 (5-9)	6.9 (5-9)	Good flavor, slightly tough mouthfeel.	Good flavor, dry mouthfeel.
Chocolate Pudding	7.4 (6-9)	7.4 (6-9)	Good flavor, good mouthfeel.	Good flavor, good mouthfeel.
Pineapple Pudding	7.3 (5-9)	7.4 (6-9)	Good flavor, good mouthfeel.	Good flavor, good mouthfeel.

TABLE VI

Panel Acceptance Evaluation of Rehydrated Bars
Before and After 3 Months Storage at 38°C.

	Panel Scores $\bar{x}$ (Range)		Comments	
	Initial	3 Months	Initial	3 Months
Orange Drink	7.6 (5-9)	8.0 (6-9)	Good orange flavor, Good mouthfeel consistency.	Good flavor, good consistency.
Hot Chocolate	7.4 (5-9)	7.9 (6-9)	Good flavor, good consistency.	Good flavor, good mouthfeel.
Cream of Mushroom Soup	6.8 (5-8)	6.9 (5-9)	Excellent flavor, good consistency.	Good flavor, good mouthfeel.
Potato Salad	7.7 (6-9)	8.0 (6-9)	Good flavor, soft consistency.	Good flavor, good consistency.
Cole Slaw	7.3 (5-9)	6.9 (5-9)	Good flavor, good mouthfeel.	Good flavor, slightly soft.
Pineapple-Cottage Cheese	7.6 (6-9)	7.4 (5-9)	Good flavor, soft consistency.	Good flavor, soft mouthfeel.
Welsh Rarebit	7.0 (5-9)	6.8 (5-8)	Good tangy flavor, excellent consistency.	Good tangy flavor, good consistency.
Crab Meat Cocktail	7.4 (5-9)	7.1 (5-9)	Good flavor, good mouthfeel.	Good flavor, not fully hydrated.
Chocolate Pudding	7.4 (5-9)	7.8 (6-9)	Very good consistency, good flavor.	Good consistency, good flavor, good mouthfeel.
Pineapple Pudding	7.3 (5-9)	7.4 (5-9)	Good consistency, good flavor.	Good consistency, good flavor, pineapple not fully hydrated.

TABLE VII

Rehydration of Compressed Bars
Before and After 3 Months Storage at 38°C.

Item	Storage	Oz. Water	Temp. of Water	Time (Min.)	Comments
Orange Drink	Initial	7	20°C.	20	Easy to crumble & rehydrate.
	3 Months	7	20°C.	20	Harder to crumble, rehydrated well.
Hot Chocolate	Initial	6	70°C.	20	Easy to crumble & rehydrate.
	3 Months	6	70°C.	20	Harder, but rehydrated well.
Cream of Mushroom Soup	Initial	5-1/2	70°C.	20	Easy to crumble & rehydrate.
	3 Months	5-1/2	70°C.	20	Easy to crumble & rehydrate.
Potato Salad	Initial	3-1/2	70°C.	20	Easy to break and rehydrate.
	3 Months	3-1/2	70°C.	20	Easy to break and rehydrate.
Cole Slaw	Initial	4	20°C.	20	Easy to break and rehydrate.
	3 Months	4	20°C.	20	Easy to break-rehydrated o.k.
Pineapple-Cottage Cheese	Initial	3	20°C.	20	Broke into pieces, rehydrated.
	3 Months	3	20°C.	20	Harder to break, rehydrated well.
Welsh Rarebit	Initial	4	70°C.	20	Easy to crumble & rehydrate.
	3 Months	4	70°C.	20	Hard to crumble & rehydrate, but o.k.
Crab Meat Cocktail	Initial	4	20°C.	20	Easy to break and rehydrate.
	3 Months	4	20°C.	20	Hard to break-rehydrated o.k.
Chocolate Pudding	Initial	5-1/2	70°C.	20	Easy to crumble & rehydrate. Good consistency after cool.
	3 Months	5-1/2	70°C.	20	Good consistency after cool.
Pineapple Pudding	Initial	5-1/2	70°C.	20	Easy to crumble & rehydrate. Good consistency after cool.
	3 Months	5-1/2	70°C.	20	Easy to crumble & rehydrate. Good consistency after cool.

SUMMARY

Ten food items have been developed, prepared and evaluated under Phase II of this contract. Two hundred fifty bars of each of the food items have been prepared and submitted to the U. S. Army Natick Laboratories for evaluation. The ten species of compressed bars were found to meet all physical, chemical and rehydration characteristics as well as panel acceptability for consumption before and after rehydration. It was found necessary to crush or break these bars into small pieces prior to placing them in water for rehydration.

The bars were prepared from dry or freeze-dried food materials by compression under relatively low product pressures. Binding agents were not required to achieve proper cohesion. However, certain products required heating of the components to increase adhesive properties and withstand handling without fragmentation. Incorporation of glycerine into certain ingredients used in the formulation of some items also aided binding characteristics as did the moisture mimetic agent.

The incorporation of glycerin into crab meat, cabbage and pineapple aided rehydration even though the purpose of its incorporation was to prevent fragmentation during compression and to aid acceptability of these items when consumed in the dry state. The use of glycerine as a conditioning agent to prevent fragmentation during compression also eliminated need to re-dry the bars after compression as was the case when water was used as a conditioning agent. The glycerine also increased the caloric density of these products.

Browning of the cole slaw was a severe problem which was difficult to overcome. This was accomplished by drying the products to less than 0.5% water content, by reducing the glycerine level, by washing the cabbage to remove free sugars and the use of sodium meta bisulfite at 2000 ppm of cabbage.

Attempts to rehydrate compressed fruits were unsuccessful and substitutes had to be made for the peaches or strawberries and cream and the fruit cocktail items.

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13. ABSTRACT

Dried foods, some plasticized to prevent fragmentation, were compressed with appropriate binders into bars of approximately equal size, density and caloric content (148 ± 25 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) Citrus Fruit Drink (2) Hot Chocolate Beverage (3) Cream of Mushroom Soup (4) German Potato Salad (5) Cole Slaw (6) Pineapple-Cottage Cheese Salad (7) Welsh Rarebit (8) Crab Meat Cocktail (9) Chocolate Pudding (10) Pineapple Fruit Pudding. 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 70°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 (fluorescence units) are recorded for each bar at the time of fabrication and after the referenced storage.

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Storage stability	8					
Food bars	9					
Compressed foods	9					
Dehydrated foods	9					
Military rations	4					