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TECHNICAL REPORT
66-29-FD

FORMULATION AND FABRICATION OF FOOD BARS

by
Jack R. Durst

The Pillsbury Company
Minneapolis, Minnesota

Contract No. DA19-129-QM-1970 (016063)

February 1966

UNITED STATES ARMY
NATICK LABORATORIES
Natick, Massachusetts 01760

Food Division
FD-39

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Food Division

U. S. ARMY NATICK LABORATORIES
Natick, Massachusetts

FOREWORD

Advanced military feeding systems require foods with maximum nutritional value, storage stability, and acceptability combined with minumum weight and volume. The development of a nutrient-defined, stable matrix composed of protein, fat and carbohydrate offers a means of achieving a high degree of control of product characteristics. Natural foods may be added to the matrix to obtain desired flavors and textures for the purpose of acceptability.

The purpose of this investigation was to develop a "universal matrix" in which various types of dehydrated foods could be dispersed and molded into compact bars. These bars would be consumed "as is" or rehydrated to a product simulating the conventional item. Acceptability studies and storage stability tests were also conducted.

Work described in this report was performed by the Pillsbury Company, Minneapolis, Minnesota, under contract number DA 19-129-QM-1970(016063). Dr. Jack R. Durst served as Official Investigator. His collaborators were Merlin J. Sletten and John R. Ringstrom.

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ABSTRACT

Formulation, production and storage studies of food bars made from various cereal products (wheat flakes, oats, rice crispies and graham crackers), as well as beef, hash and soup type bars (split pea, potato flakes), are presented. The basic matrix for the food bars is a stable binder formulated from protein (sodium caseinate), fat (lard flakes), and carbohydrate (sucrose). The binder is spray-dried, admixed with the food component, and compressed into bar form.

Final Report

SCOPE OF CONTRACT

(1) The Contractor shall formulate and fabricate six or more varieties of food bars from cereal, vegetable and/or meat ingredients. Each food bar shall meet the following requirements:

(a) The weight of the bar shall be from 1 to 2 ounces and can be square, rectangular, with or without rounded corners, etc., but must not be more than 3/4 inch thick. The bar is intended for use as one component of a four-ounce food packet, which must fit into a soldier's pocket or bandolier. The exact size requirements for the bar are not yet known, but it should be as compact as possible, consistent with other requirements.

(b) The bar will be ready to eat "as is" and capable of being quickly dissolved and made up into a soup or gruel by the addition of hot or cold water. Spices and seasonings can be separate from the bar for the purpose of making the soup or gruel more acceptable. No other preparation should be required. When the bar is eaten "as is" or when made up onto soup or gruel, it shall not be thirst-provoking.

(c) The bars will be of high acceptability, rating six or higher on a nine-point hedonic scale or equivalent rating, when eaten directly or when made up into a soup or gruel.

(d) The minimum nutritional criteria for each bar will be as follows:

(1) Minimum caloric density: -4.4 calories per gram - (125 calories per ounce).

(2) Maximum protein content: -15.0 percent of calories as protein.

(3) Maximum fat content: -35.0 percent by weight.

(e) The Contractor shall endeavor to manufacture bars which have a minimum shelf life of two (2) years at 70°F. and six (6) months at 100°F. The Contractor shall run storage tests for three (3) months at 100°F.

(f) The food bars shall have adequate packaging protection from oxygen and moisture-vapor transmission.

(2) The Contractor shall furnish the following to the designated Project Officer at the Quartermaster Food and Container Institute, 1819 West Pershing Road, Chicago 9, Illinois.

(a) Information regarding storage tests run for three (3) months at 100°F. and such other storage data and information as are available; fabrication techniques, formulation and ingredients, and all other pertinent data regarding the development work.

(b) Prototypes which the Contractor believes are highly acceptable. The number to be submitted will be determined by the Project Officer when the size of the bars and the amount of soup or gruel they make up are known. Acceptance studies will be run by the Quartermaster Food and Container Institute. If samples are not accepted, further development work will be required. Storage tests will not be initiated by the Contractor until prototypes are accepted by the Project Officer.

(c) Samples of bars which have been stored by the Contractor for three (3) months at 100°F. Number to be submitted will be determined by the Project Officer when the size of the bars and the amount of soup or gruel they make up are known. Acceptability tests will again be run by the Quartermaster Food and Container Institute.

INTRODUCTION:

While doing research work on food bars in The Pillsbury Research Laboratory, it was found that by use of a Stable Dispersion Process patented by Jack R. Durst and assigned to The Pillsbury Company that food bars could be fabricated using rather low over-all pressures. The

Pillsbury Company has agreed to the government's use of this process on the food bars covered in this contract on a royalty free basis.

The stable dispersion or encapsulation process is simply two immiscible systems, a film former in the continuous phase surrounding a liquid or once liquid discontinuous phase. The following are needed to form the stable dispersion: (1) Film former, something that is capable of forming a film around something. (2) A liquid which is immiscible in this film former. (3) A plasticizer which actually makes the film former able to form a film. (4) Proper mixing.

For our use in food bars a stable dispersion is made with known amounts of protein, fat, carbohydrates, minerals, and water. This stable dispersion is then spray-dried and mixed with the other ingredients of the food bar and placed into a die and shaped under low pressure into bars 2" x 4" x 1/4" that weigh approximately 1 oz. Depending upon the final moisture content desired in the bar and the moisture content of the stable dispersion binder, the bar is packaged as is or is dried in an air circulating oven to the desired moisture content.

Specifically, for making a stable dispersion binder we take a protein such as sodium caseinate that is hydrated or can be hydrated and limit the amount of the plasticizer which is, in this case, water, so that we have just enough of the plasticizer to form a film of protein around an oil or a liquid melted normally solid shortening which is immiscible in the protein film. This can be accomplished by simple mixing such as with a Waring Blendor or Hamilton Beach rotary mixer. Once the stable dispersion is formed, it can be diluted with additional water to give whatever viscosity is desired. Other materials such as sugars, vitamins, flavorings, minerals, colors, other proteins, preservatives, etc. may be added to the stable dispersion either before or after the formation of the dispersion depending on the desired results. For example, if one wishes to add a fat soluble

flavoring or coloring, they should be added to the liquid fat before the dispersion is formed since the fat will be encapsulated with a film of protein.

An important point in this process is that we add no emulsifiers, Emulsifiers can actually hinder or prevent the formation of a stable dispersion because they can make the water (the plasticizer) more compatible with the oil or melted normally solid fat and thus prevent the stretching of a film around the liquid fat globule. A film around a sphere is a thermodynamically stable structure.

EXPERIMENTAL:

Cereal bars were made based on work done previously at The Pillsbury Company Research Laboratories.

1. Stable Binder Dispersion Formula (1)

A stable dispersion of the following formulations was made.

Formula (1)
25.8% Non-fat milk solids
25.8% Cottonseed oil (antioxidants added)
25.8% Sucrose
6.5% Glycerin
16.1% Distilled water

The stable dispersion is formed by placing the cottonseed oil in a Waring Blendor adding the non-fat milk solids and sugar, and mixing until all the dry particles are coated with oil. The glycerin dissolved in the water is added in one increment with mixing to the material in the mixer. This is mixed one minute to form a stable dispersion and then the sides of the mixer are scraped down and mixing continued at high speed an additional minute.

A. Corn Flake Bar (1)

34.8 parts of Formula (1) were mixed with 65.2 parts of cornflakes in a Hobart Mixer. The cornflakes had previously

been broken to small pieces in the Hobart mixer. These materials were mixed together at #3 speed until no material stuck to the sides of the mixing bowl (approximately 2 minutes). Thirty grams of this material was placed into a 2" x 4" mold and 2000 lb. gauge applied (250 lb./sq. inch) using a Carver press. This gave a smooth strong bar which was quite palatable when eaten as is or could be broken up and added to water in which case it would make its own milk.

In this product the corn flakes contain 3.85 calories/gm. and the binder base 4.47 calories/gm.; therefore the bar contains 4.07 calories/gm. at 7.9% moisture. The bar contains: 8.77% protein (3.49% from binder base and 5.28% from the corn flakes), 9.25% fat (8.99% from binder base and 0.25% from the corn flakes). The bar can be further dried to 4.5% moisture by placing it in an air oven set at 80°F for 1 hour. This still gives only 4.21 calories/gm. of bar and therefore is too low for the minimum calorie content (4.4 calories/gm.) as prescribed in the scope of the contract. This ratio of fat to non-fat used in the stable dispersion binder formula (1) and the ratio of binder to corn flakes were made so that if water were added to the bar, the milk resulting would be close to the make up of regular milk. Also an oil was used to give a source of polyunsaturated fat.

B. Corn Flake Bar (2)

A 50/50 mixture of Dispersion Binder Formula (1) with corn flakes was made into a bar (as shown for Corn Flake Bar (1) and then dried to 4.5% moisture giving a bar which contain:

4.4 calories/gm.

11. Stable Binder Dispersion Formula (2)

It was noted that a small amount of oil was on the surface of the die in the 50/50 mixture. Because of this and because of the shelf life desired for the food bars, it was decided to make dispersions using melted lard flakes as the source of fat.

Formula (2) 25.8% Non-fat milk solids
25.8% Lard flakes
25.8% Sucrose
6.5% Glycerin
16.1% Distilled water

The stable dispersion is formed by melting the lard flakes at a temperature of 160°F and placing it in a Waring Blendor. The non-fat milk solids and the sugar are added and mixed with the melted lard until all the dry particles are coated with the melted lard. The glycerin is added to the distilled water which had been heated to 160°F., and this solution is added in one increment with mixing to the material in the mixer. This is mixed one minute to form a stable dispersion and then the sides of the mixer are scraped down and mixing continued at high speed for an additional minute.

Glycerine	4 calories/gm.*	0.26 calories
Sucrose	3.85 calories/gm.*	0.99 calories
Non-fat Milk Solids	3.62 calories/gm.*	0.93 calories
Lard Flakes	9.02 calories/gm.*	2.33 calories
		4.51 calories/gm. Dispersion Formula (2)

* Taken from U.S. Department of Agriculture Hand Book No. 8 " Composition of Foods - Raw, Processed, Prepared"

A. Preparation of Cereal Bars with Dispersion Binder Formula (2)

A 50/50 mixture of Dispersion Binder Formula (2) with different cereals was made into bars and dried to 4.5% moisture in an air circulating oven. The procedure was

the same as used in Corn Flake Bar (2). These results are given in Table (1).

Table (1)

Nutrients Contained in Bars Made From 50/50 Mixture of Dispersion Binder Formula (2) and Different Cereals and Dried to 4.5% Moisture

Bar Formula No.	Calories/gm.	% Protein	% Fat
Corn Flake Bar (3)	4.4	9.1	13.8
Wheat Flake Bar (1)	4.4	10.2	14.8
Rice Bar (1)	4.4	8.0	14.0
Oat Bar (1)	4.5	12.2	17.4
Graham Cracker Bar (1)	4.5	9.1	18.8

All the bars were quite palatable when eaten as is or when broken up and added to 1/2 cup water.

III. Stable Binder Dispersion Formula (3)

A stable dispersion binder was made using a higher percentage of fat and sodium caseinate as the film former.

Dispersion Formula (3)	Calories/gm.	Calories contributed to Dispersion
35.7% Lard Flakes	9.02	3.2
8.6% Sodium Caseinate	3.98	0.3
4.6% Glycerin	4	0.2
22.5% Sucrose	3.87	0.9
28.6% Distilled Water		4.6 calories/gm. total

Binder Dispersion Formula (3) contains 7.7% protein and 35.7% fat.

A. Preparation of Cereal Bars with Dispersion Binder Formula (3)

A 50/50 mixture of Dispersion Binder Formula (3) with different cereals was made into bars and dried to 4.5% moisture in an air circulating oven. The procedure was the same as used in Corn Flake Bar (2).

These results are given in Table (2).

Table (2)

Nutrients Contained in Bars made from a 50/50 Mixture of Dispersion Binder Formula (3) and Different Cereals and Dried to 4.5% Moisture

Bar Formula No.	Calories/gm.	% Protein	% Fat
Corn Flake Bar (4)	4.7	8.8	20.2
Wheat Flake Bar (2)	4.7	9.9	21.5
Rice Krispie Bar (1)	4.7	7.7	20.5
Oat Bar (2)	4.9	11.7	24.1
Graham Cracker Bar (2)	4.9	9.0	25.9

All the bars were quite palatable when eaten as is or when broken up and added to 1/2 cup water.

B. Preparation of a Hash Bar (1) with Dispersion Binder Formula (3)

A Hash Bar was made using the following formulation:

8.2% Dried Beef (Oil Immersion Dried)
38.6% Dispersion Binder Formula (3)
38.4% Pillsbury Potato Flakes
13.8% Pillsbury Brown Gravy Mix
1.0% Toasted Onions

The ingredients were mixed together in a Hobart mixer until the mixture did not adhere to the sides of the bowl (approximately 2 minutes). Food bars were made from this formulation using the same techniques as were used in Corn Flake Bar (2). The bars contained 4.5% moisture, 4.6 calories/gm., 15% protein, and 18.2% fat. This bar was quite palatable when eaten as is or when added to 1 cup hot water. Salt was added to taste.

IV. Stable Binder Dispersion Formula (4)

A stable dispersion of the following formulation was made.

Dispersion Formula (4)	Calories/gm.	Calories/gm. Contributed
39% Non-fat Milk Solids	3.62	1.41
29% Lard Flakes	9.02	2.62
7% Glycerin	4.00	0.28
25% Distilled Water		
		4.31 cal/gm. total

The technique for making the dispersion was the same as for the previous dispersion formulas. Stable Dispersion (4) contains 26.4% moisture, 4.31 calories/gm., 13.9% protein, and 29.4% fat.

A. Potato Soup With Beef Bar (1)

A Potato Soup With Beef Bar was made using the following formulations:

50% Dispersion Binder Formula (4)
37.2% Pillsbury Potato Flakes
2.5% Toasted Onions
0.6% Celery (Oil Immersion Dried)
0.4% Salt
9.2% Beef (Oil Immersion Dried)
0.1% Black Pepper

The ingredients were mixed together in a Hobart mixer until the mixture did not adhere to the sides of the bowl (approximately 2 minutes). Forty grams of this material was placed into a 2" x 4" die and 2000 lb. gauge pressure applied (250 lb/sq.inch) using a Carver press. This gives a strong bar which was further dried to 4.5% moisture by placing it in an air circulating oven set at 75°C for one hour. The bar contained 4.5% moisture, 4.51 calories/gm., 18.9% protein, and 18.7% fat. This bar was quite

palatable when eaten as is or when added to water. The preferred use with water was to crumble the bar into 1/2 cup of hot water if a gruel was desired or 1 cup of hot water if a soup was desired. Salt could be added to the soup or gruel if individual taste warrants it.

V. Scale Up Experiments

In order to make larger quantities of the better bars for preliminary evaluation by the Quartermaster Corps., attempts were made to make the dispersions in larger mixing equipment than normal laboratory size. Great difficulty was encountered because of the change of equipment. Seemingly the smaller laboratory equipment was able to do a better mixing job in the stable dispersion formulations than the larger pilot plant type mixers.

VI. New Dispersion Binder Technique

Due to the difficulty in getting consistent mixing in the larger pilot plant mixing equipment, a new technique for incorporation of the binder dispersion was evolved. This technique was as follows: Instead of limiting the amount of water added to the stable dispersion formulas to the minimum amount, enough distilled water was added to give easily mixable stable dispersions. These stable dispersions were then further diluted with water and spray dried to give dry free flowing powders of encapsulated fats which are water dispersible. (This technique was based on a patent applied process of The Pillsbury Company for making powdered fats). These free flowing binder formulas were

then dry mixed with the other ingredients of the bars, a small amount of water was added to hydrate the binder formulas and then a bar was formed by low pressure in a press. The bars could be used either as is or further dried in an air circulating oven depending on the final moisture content desired.

VII. Spray-Dried Stable Binder Formula (2)

Stable Binder Formula (2) as given previously was made and spray-dried using the following procedures:

Formulation:

400 parts non-fat milk solids
400 parts lard flakes
400 parts sucrose
100 parts glycerin
575 parts distilled water

The stable dispersion was formed by heating the lard flakes to 160°F adding the sucrose and non-fat milk solids and blending together until all the solids were coated with melted lard. 325 parts of the distilled water plus the 100 parts of glycerin dispersed in the water were heated to 160°F and then added with rapid mixing to the slurry. A stable dispersion was formed after approximately 1 minute mixing at high speed in a gallon size Waring Blendor. After the dispersion was formed, the additional 250 parts of water were added to dilute it for spray drying. The diluted stable binder formula (2) was then spray-dried using a Bowen type spray drier which employs a centrifugal head. Stable, free-flowing water dispersible powders of the following composition resulted.

	Calories/gm.	Calories/gm. Contributed
30.17% Non-fat milk solids	3.62	1.09
30.17% Lard Flakes	9.02	2.72
30.17 Sucrose	3.85	1.16
7.59% Glycerin	4.00	0.30
1.90% Water		
	Total	5.27 cal/gm.

The Spray-Dried Formula (2) contained 5.27 calories/gm., 10.7% protein, 30.2% fat and 1.9% moisture.

A. Preparation of Cereal Bars and Graham Cracker Bar with Spray Dried Dispersion Binder Formula (2)

Formula: 52% Cereal flakes or Graham Crackers
45% Spray Dried Binder Formula (2)
3% Distilled Water

Procedure: The cereal flakes or graham crackers and Spray-Dried Formula (2) were mixed together at high speed using a Hobart mixer for a period of 3 to 4 minutes until they were broken into smaller pieces (approximately 1/16 to 1/8 inches across). The Hobart mixer was set at number 2 speed and the water slowly dropped in while the mixing continued. Forty gram units of the resulting free flowing mixture were placed into 2" x 4" dies and pressed into a bar using 125 lb/sq. inch pressure. These bars could be used as is, but superior bars resulted after they were dried for 20 minutes in an air circulator oven set at 50°C. The nutrients of the different bars are given in Table (3).

Table (3)

Nutrients Contained in Bars Made from Cereal Flakes or Graham Cracker and Spray Dried Dispersion Binder Formula (2)

Bar Formula No.	Calories/gm.	% Protein	% Fat	% Moisture
Corn Flake Bar (5)	4.4	9.1	14.0	4.7
Wheat Flake Bar (3)	4.4	10.5	14.5	4.8
Rice Krispie Bar (2)	4.5	8.0	14.0	4.6
Oat Bar (3)	4.5	12.4	17.4	4.9
Graham Cracker Bar (3)	4.5	9.1	19.0	5.8

All of these bars were quite palatable when eaten as is or when added to 1/2 cup water.

VIII. Hardness of Food Bars

It was found that the final hardness of the food bars could be controlled by the following variations.

1. Amount of water added to bar ingredients before pressing.
2. Amount of glycerin added.
3. Pressure applied.
4. Particle size of ingredients.
5. Time after water was added until bar was made.

By using the above variables or combinations of variables, it is possible to make bars of the same formulation which vary in hardness from almost rock-like to very fragile. We have attempted to make our bars strong yet still be able to be broken up with the fingers so that they can be used for a soup or gruel.

IX. Spray Dried Stable Binder Formula (7)

From the success achieved in making the Spray Dried Binder (2), we formulated and spray dried a stable binder dispersion which was not as sweet as Binder (2) so that it could be used in bars

suitable for soups.

Formulation

43.2% Nonfat milk solids
42.9% Lard flakes
6.9% Sucrose
7.0% Glycerin

The techniques for making the stable dispersion and subsequent spray drying were the same as given for Spray-Dried Stable Binder Formula (2). No difficulty was encountered in spray drying this binder formulation using a laboratory size Bowen spray drier.

The spray dried formula (7) contained 5.98 calories/gm., 15.38% protein, 42.9% fat, and 1.9% moisture.

X. Scale Up Production of Stable Binder Formulations (2) and (7)

Pilot plant runs were made for Stable Binder Formulations (2) and (7). In both cases no trouble was encountered in making the stable dispersions prior to spray drying. Trouble was encountered when we tried to spray dry these formulations in our Blaw-Knox spray drier. The material hung up on the walls and the encapsulation broke when conveyed by the screw-type conveyor at the bottom of the drier. Samples were collected from the walls of the drier and were found to be hygroscopic when placed open in the air. From these difficulties it was decided to remove the glycerin from the formulations and replace it with an equal amount of sucrose. The new formulations were:

Stable Binder Formulation (2) (a)	Stable Binder Formulation (7) (a)
30.75% Non-fat milk solids	43.2% Non-fat milk solids
30.75% Lard flakes	42.9% Lard flakes
38.50% Sucrose	13.9% Sucrose

Since the calories/gm. content of glycerin and sucrose are essentially the same (they are both carbohydrates), no change in calorie content, protein, or fat was made from the original formulas.

The pilot plant run for Binder Formulation (2) (a) was made using the following quantities:

23.2 lb. Non-fat milk solids
23.2 lb. Lard flakes
29.0 lb. Sucrose
80.8 lb. Water

The lard flakes were heated in a steam jacketed kettle to 160° F so that they were completely melted. The nonfat milk solids and sucrose were then added and mixed with the melted lard flakes until completely coated. 43.3 lb. of hot (160° F) water were added with rapid agitation. The material was then pumped through an Oakes mixer and recirculated until a stable dispersion resulted (35 minutes). An additional 37.5 lbs. of hot (160°F) water were added to the stable dispersion to reduce the viscosity for spray drying. The material was pumped through a Manton Gaulin pump at 1000 - 1200 p.s.i. and then through a spray nozzle containing a No. 67 Orifice with a No. 17 insert into a Blaw-Knox Horizontal Spray Drier. The inlet air temperature was 230° - 240°F., and the outlet air temperature was 170° - 175° F. The resulting product was a stable, free-flowing white powder.

The pilot plant run for Binder Formulation (7) (a) was made using the following quantities:

32.4 lb. Non-fat milk solids
32.2 lb. Lard flakes
10.4 lb. Sucrose
75.25 lb. Water

Binder Formula (7) (a) was made by the same procedures and techniques given for Binder Formula (2) (a).

XI. Use of Spray Dried Binder Formula (2) (a)

Cereal Bars and Graham Cracker Bars were made using the same formulations, techniques, and procedures given under VII A, replacing Spray Dried Binder Formula (2) with 2(a). Similar products resulted indicating that the glycerine was not necessary to the binder formulation. The bars made were: Corn Flake Bar (6); Wheat Flakes Bar (4); Rice Krispies Bar (3), and Graham Cracker Bar (4).

XII. Use of Spray Dried Binder Formula (7) (a)

A. Hash Bar (2)

A Hash Bar of the following formulation was made:

9.2% Oil Immersion Dried Beef
30.0% Spray Dried Binder Formula (7) (a)
40.4% Pillsbury Potato Flakes
14.4% Pillsbury Brown Gravy Mix
1.0% Toasted Onions
5.0% Water

All of the dry ingredients were mixed together in a Hobart mixer until the particles were quite small. The Hobart mixer was set at number 2 speed and the water slowly dripped in while the mixing continued. 40 grams of the resulting free flowing mixture was placed into a 2" x 4" mold in a Carver press and pressed into a bar using 500 lb./sq. in. pressure. These bars could be used as is, but superior bars resulted if they were dried for 20 minutes in an air circulating oven set at 50° C. The resulting bar contained 8.2% moisture, 4.4 calories/gm., 16.77 protein, and 15.4% fat. This bar was thought to be quite palatable when eaten as is or when added to water. The recommended amount of water to each bar was 1/2 cup of hot water if a gruel was desired and 1 cup of hot water if a soup was desired. It was also recommended that 1.5 grams of salt be added to each bar if it was to be eaten as a soup or gruel.

B. Potato Soup with Beef Bar (2)

A Potato Soup With Beef Bar of the following formulation was made.

43.6% Pillsbury Potato Flakes
38.0% Spray-Dried Binder Formula (7) (a)
9.2% Oil Immersion Dried Beef
2.5% Onion Flakes
0.6% Oil Immersion Dried Celery
1.0% Salt
0.1% Black Pepper
5.0% Distilled Water

The same techniques as were used for Hash Bar (2) were employed. The resulting bar contained 7.4% moisture, 4.5 calories/gm., 18.1% protein, and 18.9% fat. This bar was thought to be quite palatable when eaten as is or when added to water. The amount of water recommended for each bar was 1/2 cup of hot water if a gruel is desired and 1 cup of hot water if a soup was desired. It was also recommended that 1.5 grams of salt be added to each bar if it was to be eaten as a soup or gruel.

It was found both for the Hash Bar and the Potato Soup With Beef Bar that care must be exercised that the bars be immediately pressed out after water addition to insure proper hydration of the binder. If one waits too long (longer than 1/2 hour), the potato flakes will absorb the moisture from the binder and thus prevent proper bonding. This phenomenon has some advantage in that bars can be immediately pressed out and then hardened by the dehydration of the binder by the potato flakes thus holding the bar more rigidly. This is accomplished because the potato flakes are low in moisture (7.0%), and potato starch normally contains 12% moisture; therefore the potato flakes are water deficient and will in time remove the water from the binder.

C. Split Pea Bar (4)

A Split Pea Bar of the following formulation was made:

30%	Spray-Dried Cooked Split Pea Powder
46%	Spray-Dried Binder Formula (7) (a)
2%	Smoked Yeast Flavor
1%	Salt
1%	Onion Powder
0.2%	Black Pepper
0.2%	Monosodium Glutamate
7.8%	Potato Granules (Rogers Bros.)
7.8%	Potato Flakes (Pillsbury)
4.0%	Water

The same techniques as were used for Hash Bar (2) were employed except only 250 p.s.i. pressure was used to form the bars instead of the 500 p.s.i. used for the Hash Bar (2). The resulting bar contained 7.1% moisture, 4.5 calories/gm., 17.0% protein, and 20.6% fat. The bar was thought to be quite palatable when eaten as is or when added to water. The amount of water and added salt recommended for each bar was the same as for the other soup type bars.

XIII. Bars Sent to the Armed Forces Food and Container Institute for Evaluation

1. Corn Flake Bar (6)
2. Wheat Flake Bar (4)
3. Rice Krispies Bar (3)
4. Oat Bar (3) Contains Glycerin
5. Graham Cracker Bar (4)
6. Hash Bar (2)
7. Potato Soup with Beef Bar (2)
8. Split Pea Bar (4)

The food bars were evaluated by a consumer panel and by a technical panel at the Institute. Results were as follows:

Table (4)

A. Consumer Panel Acceptance Results of Food Bars

Bars	Eaten "as is"	As a Soup	As a Gruel
Corn Flake Bar (6)	6.44	-	4.40
Wheat Flake Bar (4)	5.88	-	3.95
Rice Krispies Bar (3)	5.90	-	4.32
Oat Bar (3)	5.78	-	4.02
Graham Cracker Bar (4)	6.17	-	3.95
Hash Bar (2)	4.09	6.03	-
Potato Soup with Beef Bar (2)	3.90	5.72	-
Split Pea Bar (4)	4.24	6.03	-

The consumer panel consisted of 40 people and the above results are hedonic ratings based on a nine-point hedonic scale. The soup bars rated poorly when eaten "as is" but had good acceptance when eaten as a soup. The remaining bars had good acceptance when eaten "as is" but rated poorly when made into a gruel.

The soup bars were broken up and made into a soup using 8 fluid ounces of near boiling water per bar, and the remaining bars were broken up and made into a gruel using 4 fluid ounces of cool water per bar.

It was found that a minimum quantity of 2.0 grams of salt per bar was required when the soups were prepared as indicated above. In addition to this amount of salt, the individuals on the panel were told that they could add salt if they should desire.

The cereal bars and the graham cracker bar were made up into gruels without the addition of other ingredients. There was some question as to how long the gruels had to "set" prior to being eaten.

B. Technical Panel Acceptance Results

1. All the cereal bars and the graham cracker bar had good

acceptability when they were eaten "as is". Some comments were that the graham cracker bar "stuck to the teeth" and was "gummy" during the process of being chewed. However, the latter was not the general consensus of opinion.

2. The soup bars had poor acceptability when eaten "as is". This may be due to the fact that the seasonings in the bars may have been too "overpowering." A more balanced flavor may be required.

3. All the cereal bars and the graham cracker bar had poor acceptability when they were made into gruels. Each bar was broken up by hand into 4 fluid ounces of cool water, stirred, left to stand for approximately five minutes, stirred again vigorously, and then eaten. It was not known how long this mixture should "set" prior to being eaten for the best acceptability. All the gruels with the exception of the graham cracker gruel had a "white scum." The panel felt that there was evidence of fat separating out. There was some discussion in regards to "encapsulation" - that is, whether this method actually prevents various fats from separating out when bars such as the above are made into gruels and soups. All the cereal bars were considered too hard. Large chunks were formed when they were broken by hand, when in the process of making gruels. It was believed that these bars should have the consistency of the soup bars. The graham cracker bar was extremely hard and therefore very difficult to break up by hand.

4. The soup bars had a good acceptability when made into a soup using 8 fluid ounces of near boiling water per bar. When they were crumbled by hand, crumbs formed rather than "chunks" and in a comparatively short time these crumbs dissolved. However, fat separation was noticed again as in the gruels when the soup cooled

down to about 100°F. The pea soup was the worst as far as fat separation is concerned.

The technical panel concluded that additional development work was required before storage tests were conducted. It was felt that more work should be performed in the following areas:

1. Cereal Bars and Graham Cracker Bar

   a. Develop cereal bars and graham cracker bar which will crumble into small pieces rather than "chunks" when broken up by hand. Determine approximate size of pieces and length of time pieces will need to remain in water prior to eating to give the highest degree of acceptance.

   b. Develop gruels which will be appetizing in appearance - eliminating the formation of white scum with fat.

   c. Determine what additional ingredients (and amounts) will bring about a high degree of acceptance when added to the gruels.

2. Soup Bars

   a. The present bars, when eaten "as is", have an "overpowering" effect and some flavors seem to "hang on" resulting in some discomfort. Develop bars which have a proper balance of seasonings. The soups are acceptable, but apparently ingredients which are appealing in the soups are not appealing in the bars when they are eaten "as is".

   b. Fat separated and congealed when temperature of soup was approximately 100°F. Actually no fat separation should be evident when the temperature of the soup is

reduced to 70°F. The soups must be acceptable when near-boiling water and when cool water (70°F) is used. At times the soldier may have to use water from his canteen and may not be able to heat or boil the water. Fat separation was quite evident in the made-up pea soup.

c. Determine what additional ingredients (and amounts) will bring about a high degree of acceptance when added to the soups.

XIV. Attempts to Make Cereal Bars To Conform To the Recommendations of the Armed Forces Food and Container Institute

The biggest drawbacks to the cereal bars submitted to the Institute were:

1. Bars were too hard to properly crumble when broken by hand.
2. A white scum appeared on the surface after the bars were made up into a gruel.
3. The bars did not hydrate rapidly enough when placed in water.

It was believed that the cause of these shortcomings was due to the nature of the fat used in the Binder Formulations. Since we used lard flakes which are normally solid at room temperature and mouth temperature, some creaming of the fat occurs when water is added. Also, if some of the encapsulation is broken during manufacture of the bars, the free fat will be of the solid type and thus readily apparent when eaten or viewed in a cold water gruel.

To eliminate these shortcomings a high stability oil (Kex oil - Durkee Company) with a AOM stability greater than 100 hours was substituted for the lard flakes in Spray Dried Binder Formulations (2) (a) and (7) (a).

The new formulations are as follows:

Binder Formulation (2) (b)	Binder Formulation (7) (b)
30.75% Nonfat Milk Solids	43.2% Nonfat Milk Solids
30.75% Kex Oil	42.9% Kex Oil
38.50% Sucrose	13.9% Sucrose

70 pounds each of these two Binder Formulations were made using the same techniques and procedures as given for Spray-Dried Binder Formulations (2) (a) and (7) (a) except they were homogenized at 4000 p.s.i. before spray drying. Stable, white, free flowing powders which readily disperse in water resulted from these runs. The calorie contents, moisture, proteins, and fats contents were the same as those given for Spray-Dried Binder Formulations (2) and (7).

XV. Use of Spray Dried Binder Formulation (2)(b) To Make Cereal Bars

A. Corn Flake Bar (7)

A corn flake bar with the same formulation as Corn Flake Bar (4) was made substituting Spray-Dried Binder Formulation (2)(b) for (2)(a). The techniques for making the bar were the same as those given previously for Corn Flake Bar (5).

A bar resulted that was quite palatable when eaten as is or when broken up and added to 1/2 cup of cold water to make a gruel. No white scum or fat specks were apparent, and no fat "mouth-feel" was evident. The corn flake gruel tasted very much like regular corn flakes, sugar, and milk that one would eat for breakfast.

B. Preparation of Corn Flake Bar (7) and Oat Bar (4) For Evaluation By the Armed Forces Food and Container Institute

Since we felt that we had overcome the majority of the shortcomings of the previous bars submitted to the Institute, we made corn flake and oat bars of a given hardness as representative samples

for the cereal type bars to be sent to the Institute for evaluation. The Corn Flake Bar (7) was made as given previously with the following exception: Instead of adding the water last after mixing the corn flakes and binder, the water was added to the broken corn flakes before the binder was added. This insured a proper distribution of the water on the surface of the corn flakes, and when the binder was added, it stuck evenly to the surface of the corn flakes with no balling up, thus giving a more uniform bar. The pressure used to form the bar was 250 p.s.i.

Oat Bar (4) was formed in the same way as Corn Flake Bar (7) using the formulation of Oat Bar (3) and replacing Spray-Dried Binder Formulations (2) with (2) (b).

C. Evaluation of Corn Flake Bar (7) and Oat Bar (4) By The Armed Forces Food and Container Institute

It was reported by the Institute that the bars had good acceptability when made up into a gruel with no fat specks noted and no fat "mouth feel" evident. However, it was stated that the bars themselves were too soft; that is, they crumbled and broke very easily. The Institute felt that these bars possibly would have good acceptability if they had the "hardness" or consistency somewhere between the consistency of bars made with Binder (2) (a) and the consistency of the corn flake bar (7) and Oat Bar (4).

D. Preparation of Harder Corn Flake Bar (7) and Oat Bar (4)

A harder corn flake bar (7) was accomplished by simply raising the pressure to 500 p.s.i. when pressing out the bar. A harder oat bar (4) was accomplished by increasing the water added from 3% to 5% and then pressing the bar at 500 p.s.i.

E. Evaluation of Harder Corn Flake Bar (7) and Oat Bar (4) By The Armed Forces Food and Container Institute

The Institute accepted the Corn Flake Bar (7) and Oat Bar (4) as representative of the cereal bars and thus approved the beginning of three months storage tests.

XVI. Attempts to Make Soup Type Bars to Conform to the Recommendations of the Armed Forces Food and Container Institute

Two results noted by the Armed Forces Food and Container Institute concerning the soup type food bars submitted to the Institute were that the bars, when eaten "as is" have an overpowering effect and some flavors seem to "hang on" resulting in some discomfort and that fat separated and congealed when temperature of the soup was approximately 100°F.

To help alleviate the overpowering effect, some of the flavorings were lowered. The fat separation was eliminated by replacing the fat (lard flakes) in the binder with a high stability vegetable oil (Kex) (Spray-dried Binder Formulation (7)(b)).

A. Preparation of Hash Bar (3)

Formulation:	8.2%	Freeze-Dried Beef
	35.5%	Spray-Dried Binder 7(b)
	43.0%	Potato Flakes (Pillsbury)
	7.2%	Brown Gravy Mix (Pillsbury)
	0.5%	Onion Flakes
	0.05%	Black Pepper
	0.05%	Beefatone (Ottens-Quaker Brand)
	0.5%	Salt
	5.0%	Distilled Water

Procedure: The freeze-dried beef was reduced in size by mixing in a Hobart mixer and then the potato flakes were added followed by the seasoning combined with the binder. Mixing was continued (#2 speed) until the ingredients were well mixed (approximately 1 minute). The water was then added with continued mixing. The product was made into

2" x 4" x 1/4" bars weighing approximately 40 grams by using dies and a Dennison hydraulic press. The pressure used was 750 lb/sq. inch with a 5 second hold down. These bars were then dried for 20 minutes in an air circulating oven set at 50°C. The dried bars were packaged into mylar-vinyl lined aluminum foil pouches. The resulting bars contained 7.77% moisture, 4.4 calories/gm., 17.3% protein, and 16.3% fat. The bar can be made into a gruel by breaking up by hand into 1 cup of hot water or into a soup by breaking up into 1 1/2 cups of hot water. It was recommended that 1 1/2 grams of salt be added to each bar when eaten as a soup or gruel.

B. Preparation of Potato Soup With Beef Bar (3)

Formulation:

8.2%	Freeze-Dried Beef
39.4%	Spray-Dried Binder 7(b)
45.2%	Potato Flakes (Pillsbury)
0.6%	Freeze Dried Celery
1.0%	Salt
0.5%	Onion Powder
0.05%	Black Pepper
0.05%	Beefatone (Ottens-Quaker brand)
5.0%	Distilled Water

Procedure: The procedure for manufacture was the same as for the Hash Bar (3) except the freeze dried celery was broken up with the meat, and the binder was added before the potato flakes. The bars contained 7.44% moisture, 4.4 calories/gm., 17.3% protein, and 18.0% fat. The recommended water and salt additions were the same as for the Hash Bar.

C. Preparation of Split Pea Bar (5)

Formulation:

30.8% Split Pea Powder (Spray-Dried)
46.8% Spray-Dried Binder Formula 7(b)
1.0% Smoked Yeast Flavor
0.5% Onion Powder
0.1% Black Pepper
0.2% Monosodium Glutamate
1.0% Salt
7.8% Potato Granules (Rogers Bros.)
7.8% Potato Flakes (Pillsbury)
4.0% Distilled Water

Procedure: The procedure was the same as for the Hash Bar (3) except the hold down time on the press was 0.3 seconds. The bars contained 7.1% moisture, 4.5 calories/gm., 16.8% protein, and 20.9% fat. The bar was made up into a gruel by breaking up by hand into 1/2 cup hot water or into a soup by breaking up into 1 cup of hot water. It was recommended that 1 1/2 grams of salt be added to each bar when eaten as a soup or gruel.

XVII. Evaluation of Soup Type Bars by The Armed Forces Food and Container Institute

12 bars of each of the Hash Bar (3), Potato Soup with Beef Bar (3), and Split Pea Bar (5) were sent to the Armed Forces Food and Container Institute for evaluation. The following evaluation was given:

Table (5)

EVALUATION OF SOUP TYPE BARS BY THE ARMED FORCES FOOD AND CONTAINER INSTITUTE

Soup Bars	Eaten "as is" Hed. Rating	Made up as a Soup Hed. Rating
Split Pea Bar (5)	4.67	5.19
Hash Bar (3)	4.88	4.64
Potato Soup with Beef Bar (3)	4.33	4.42

Even though the ratings did go up over the original bars submitted (Table (4) when eaten "as is", the ratings dropped more when eaten as a soup. Because of the lower ratings when eaten as a soup, it was decided to add a separate seasoning packet to each of the bars which

could be added when they were eaten as a soup.

XVIII. Formulation of Seasoning Packets to be Added to the Soup Type Bars

Seasoning packets were formulated for Hash Bar (3), Potato Soup with Beef Bar (3) and Split Pea Bar (5). These seasoning packets were based upon the seasoning levels used for the Hash Bar (2), Potato Soup with Beef Bar (2), and Split Pea Bar (4). The seasoning packets were made so that one packet would be added to a bar weighing approximately 40 gm.

The seasoning packets contained the following ingredients:

1. Hash Bar Seasoning Packet

   2 gm. Salt
   3 gm. Pillsbury Brown Gravy Mix
   0.2 gm. Onion Flakes

2. Potato Soup with Beef Bar Seasoning Packet

   2.5 gm. Salt
   1.0 gm. Onion Flakes
   0.02 gm. Black Pepper

3. Split Pea Bar Seasoning Packet

   1.5 gm. Salt
   0.4 gm. Onion Flakes
   0.2 gm. Onion Powder

The bars were made up into a soup by adding the seasoning packets to hot water prior to the addition of the crumbled soup bar. The Hash Bar and Potato Soup with Beef Bar were made into a gruel by crumbling by hand into 3/4 cup hot water or into a soup into 1 1/4 cups hot water. The Split Pea Bar was made into a gruel by crumbling by hand into 1/2 cup hot water or into a soup into 1 cup of hot water. The soups could be eaten approximately 5 minutes after they were broken up and stirred into the hot water.

XIX. Evaluation of Soup Type Bars with Added Seasoning Packet by The Armed Forces Food and Container Institute

Bars of Hash Bar (3), Potato Soup with Beef Bar (3) and Split Pea Bar (5) plus seasoning packets as given in Section XVIII were sent to the Armed Forces Food and Container Institute for evaluation. The bars were evaluated "as is" without seasoning packets and as soups with the added seasoning packets. The following results were obtained.

Table (6)

EVALUATION OF SOUP TYPE FOOD BARS PLUS SEASONING PACKETS BY THE ARMED FORCES FOOD AND CONTAINER INSTITUTE

Soup Bar	Eaten "As Is" Hed. Rating	Made Up as a Soup Hed. Rating
Split Pea Bar (5)	4.36	4.72
Hash Bar (3)	4.17	5.70
Potato Soup with Beef Bar (3)	4.47	5.67

Table (6) shows the soup type bars with added seasoning packets rated approximately as good as the original bars with higher seasoning with the exception of the Split Pea Bar. Therefore, the Institute recommended that storage tests be initiated on the Hash Bar (3) with seasoning packet and Potato Soup with Beef Bar (3) with seasoning packet. Additional work was recommended for Split Pea Bar (5) so that it will be more acceptable as a bar and as a soup.

XX. Additional Work on Split Pea Bar

Additional work was recommended on the Split Pea Bar to make it more acceptable both as a dry bar and as a soup. Table (4) shows that Split Pea Bar (4) was acceptable as a soup but Split Pea Bar (5) with added seasoning packet was not (Table 5). Since the seasoning packet gave Bar (5) the same seasoning as Bar (4), it can possibly be assumed that the split peas themselves were the cause. There was a difference in processing and brands of the split peas used for Bar (4) and Bar (5).

Bar (4) split peas were of Red River Valley brand which were cooked in the laboratory and spray-dried in a laboratory size Bowen Spray Drier. Bar (5) split peas were of Minnesota Bean and Pea Company brand and were cooked in 50 lb. lots in the pilot plant and spray-dried in a Blaw Knox spray drier. It was also noted that the pilot plant spray dried split pea powder was more yellow in color than that made in the laboratory.

To check this concept, bars were made using the spray-dried split pea powder made in the pilot plant and from a commercial green pea powder made by CVC (Vacu-Dry Company of Oakland, California). Formula (4) and Formula (5) plus seasoning packet were used for both of the pea powders. A technical panel evaluated the bars. The results were given in Table (7).

Table (7)

EVALUATION OF DIFFERENT PEA POWDERS USING FORMULA (4) AND FORMULA (5) PLUS SEASONING PACKET

Pea Powder	Formula	Made Up as a Soup Hed. Rating
Pilot Plant	4	4.50
CVC	4	4.75
Pilot Plant	5 plus seasoning packet	5.75
CVC	5 plus seasoning packet	6.00

Table (7) shows that there was a preference of one formula over the other, namely Formula 5 plus seasoning packet over Formula 4, but no significant difference between pea samples.

It appears that much more work would be required to determine why we obtained lower ratings on Split Pea Bar (5) plus seasoning packets by the Armed Forces Food and Container Institute. Therefore, we decided that there would not be enough time remaining in the present contract and must drop the Split Pea Bar. Since the contract calls for 6 bars,

there still will be 7 bars remaining for storage tests.

XXI. Preparation of Cereal Bars and Graham Cracker Bar for Storage Tests

A. Preparation of Corn Flake Bar (7) for Storage Studies

Formulation: 45% Binder 2b.
52% Corn Flakes
3% Water

Procedure: Mix and break up the corn flakes in a Hobart mixer for 45 seconds using a flat paddle and #2 speed, add water (25 seconds) with continued mixing and then add binder and mix an additional 15 seconds. The bars were made by filling dies in a Dennison hydraulic press with approximately 40 gm. of material and pressing at 750 lb/sq. in. using a minumum hold down. These bars were dried for 20 minutes in an air circulating oven set at 50°C. and then packaged hot.

B. Preparation of Wheat Flake Bar (5) for Storage Studies

Formulation: 45% Binder 2b
52% Wheat Flakes
3% Water

Procedure: Same as for Corn Flake Bar (7) except 50 seconds required to initially break up the flakes to proper size.

C. Preparation of Rice Krispies Bar (4) for Storage Studies

Formulation: 45% Binder 2b
51% Rice Krispies
4% Water

Procedure: Same as for Corn Flake Bar (7) except 60 seconds were required to initially break up the Krispies to proper size and 30 seconds were required to add the water.

D. Preparation of Oat Bar (4) for Storage Studies

Formulation: 44% Binder 2b
51% Cheerios (Commercial Oat Cereal)
5% Water

Procedure: Same as for Corn Flake Bar (7) except the Cheerios were broken up initially by passing between a rubber coated roller and a steel roller.

E. Preparation of Graham Cracker Bar (5) for Storage Studies

Formulation: 45% Binder 2b
53% Graham Crackers
2% Water

Procedure: Same as for Corn Flake Bar (7) except 60 seconds were required to initially break up the graham crackers to proper size and 20 seconds were required to add the water.

XXII. Storage Studies for Cereal Bars and Graham Cracker Bars

The contract called for a 3 months storage test of the bars packaged in adequate packaging protection from oxygen and moisture-vapor transmission. For this package we used (A) 0.5 mil mylar-0.00035 inch aluminum foil - 3 mil vinyl (polyvinyl chloride) pouch stock. These bars were stored in a 100°F and 50% relative humidity room. In addition to this, bars were packaged in (B) Cellophane (Avis Co. RS-2-195(PS737), (C) 1 mil low density polyethylene (PS691), (D) 0.75 mil capron (nylon) - Vicon (saran) dispersion - 2 mil low sensity polyethylene (PS734) and (E) Glass Jar - nitrogen packed. These packaged bars were placed in a cycling room which varied from 76° F and 74% relative humidity to 90° F and 78% relative humidity. This is regarded by packaging engineers as a rougher test than just 100°F. storage. The test was designed so that product could be tested at 2 weeks, 4 weeks, 8 weeks, 13 weeks (3 months), 26 weeks, and 52 weeks. Forty seven additional bars were stored in the 100°F room packed in the foil pouch stock to be sent to the Armed Forces Food and Container Institute after a three months storage period. The bars were tested for appearance, smell, taste "as is", dispersibility in water, taste as a gruel, and moisture content.

Table (8)

Thirteen Week Storage Test of Corn Flake Bar (7)

Test	2 Week					4 Week					8 Week			13 Week		
	100°F Room	Cycling Room				100°F Room	Cycling Room				100°F Room	Cycling Room		100°F Room	Cycling Room	
	A	B	C	D	E	A	B	C	D	E	A	D	E	A	D	E
Appearance	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK
Smell	OK	Off	Off	OK	OK	OK	Off	Off	OK	OK	OK	Off	OK	OK	OK	OK
Taste "as is"	OK	Off	Off	OK	OK	OK	Off	Off	OK	OK	OK	OK	OK	OK	OK	OK
Taste - gruel	OK	Off	Off	OK	OK	OK	-	-	OK	OK	OK	lack sweet-ness	OK	OK	OK	slightly stale
Dispersibility in Water	OK	OK	OK	OK	OK	OK	-	-	OK	OK	OK	OK	OK	OK	OK	OK
% Water*	3.98	4.30	4.34	4.33	4.21	3.96	5.96	5.42	4.72	3.87	3.42	4.81	3.50	4.03	5.74	5.60
Comments	Good	a	a	Good	Good	Good	b	b	Good	Good	Good	OK	Good	Good	Good	Poor seal

a = Picked up odors and taste from cycling room

b = Bad product - picked up odors, taste, and moisture from cycling room

* = Moisture determined by drying 6 hours in a vacuum oven set at 26 inches of vacuum and 70° C.

A = 0.5 mil mylar -0.00035 inch aluminum foil - 3 mil vinyl (polyvinyl chloride) pouch stock
B = Cellophane (Avis Co. RS-2-195 (PS737)
C = 1 mil low density polyethylene (PS691)
D = 0.75 mil capron (nylon-Vicon (saran) dispersion - 2 mil low density polyethylene (PS734)
E = Glass Jar - nitrogen packed

The 100°F Room contains 50% RH and Cycling Room varied from 76°F and 74% RH to 90°F and 78% RH

Table (9)

Thirteen Week Storage Test of Wheat Flake Bar (5)

Test	2 Week					4 Week					8 Week			13 Week		
	100°F Room	Cycling Room				100°F Room	Cycling Room				100°F Room	Cycling Room		100°F Room	Cycling Room	
	A	B	C	D	E	A	B	C	D	E	A	D	E	A	D	E
Appearance	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK
Smell	OK	Off	Off	OK	OK	OK	Off	Off	slight poly	OK	OK	OK	OK	OK	OK	OK
Taste "as is"	OK	Off	Off	OK	OK	OK	Off	Off	OK	OK	OK	OK	OK	OK	OK	OK
Taste - gruel	OK	Off	Off	OK	OK	OK	-	-	OK	OK	OK	lack sweet-ness	OK	OK	OK	OK
Dispersibility in Water	OK	OK	OK	OK	OK	OK	-	-	OK	OK	OK	OK	OK	OK	OK	OK
% Water *	4.20	4.29	4.10	3.89	3.49	4.38	5.54	5.13	5.03	3.53	3.57	4.83	3.13	3.62	5.76	3.43
Comments	Good	a	a	Good	Good	Good	b	b	Good	Good	Good	OK	Good	Good	OK	Good

a = Picked up odors and taste from cycling room

b = Bad product - picked up odors, taste, and moisture from cycling room

* = Moisture determined by drying 6 hours in a vacuum oven set at 26 inches of vacuum and 70°C.

A = 0.5 mil mylar -0.00035 inch aluminum foil - 3 mil vinyl (polyvinyl chloride) pouch stock
B = Cellophane (Avis Co. RS-2-195 (PS737)
C = 1 mil low density polyethylene (PS691)
D = 0.75 mil capron (nylon-Vicon (saran) dispersion - 2 mil low density polyethylene (PS734)
E = Glass Jar - nitrogen packed

The 100°F Room contains 50% RH and Cycling Room varied from 76°F and 74% RH to 90°F and 78% RH

Table (10)

Thirteen Week Storage Test of Rice Krispie Bar (4)

Test	@ Week 100°F Room A	@ Week B	@ Week Cycling Room C	@ Week Cycling Room D	@ Week Cycling Room E	4 Week 100°F Room A	4 Week B	4 Week Cycling Room C	4 Week Cycling Room D	4 Week Cycling Room E	8 Week 100°F Room A	8 Week Cycling Room D	8 Week Cycling Room E	13 Week 100°F Room A	13 Week Cycling Room D	13 Week Cycling Room E
Appearance	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK
Smell	OK	Off	Off	OK	OK	OK	Off	Off	OK	OK	OK	OK	OK	OK	OK	OK
Taste "as is"	OK	Off	Off	OK	OK	OK	Off	Off	OK	OK	OK	slightly stale	OK	OK	OK	OK
Taste - gruel	OK	Off	Off	OK	OK	OK	-	-	OK	OK	OK	fair	OK	OK	OK	OK
Dispersibility in Water	OK	OK	OK	OK	OK	OK	-	-	OK	OK	OK	OK	OK	OK	OK	OK
% Water *	4.36	4.34	4.51	4.24	3.91	4.71	6.31	5.25	5.33	4.61	4.19	5.15	3.85	4.23	6.28	4.48
Comments	Good	a	a	Good	Good	Good	b	b	Good	Good	Good	Fair	Good	Good	Good	Good

a = Picked up odors and taste from cycling room

b = Bad product - picked up odors, taste, and moisture from cycling room

* = Moisture determined by drying 6 hours in a vacuum oven set at 26 inches of vacuum and 70° C.

A = 0.5 mil mylar -0.00035 inch aluminum foil - 3 mil vinyl (polyvinyl chloride) pouch stock
B = Cellophane (Avis Co. RS-2-195 (PS737)
C = 1 mil low density polyethylene (PS691)
D = 0.75 mil capron (nylon-Vicon (saran) dispersion - 2 mil low density polyethylene (PS734)
E = Glass Jar - nitrogen packed

The 100°F Room contains 50% RH and Cycling Room varied from 76°F and 74% RH to 90°F and 78% RH

Table (11)

Thirteen Week Storage Test of Oat Bar (4)

Test	2 Weeks					4 Weeks					8 Weeks			13 Weeks		
	100°F Room	Cycling Room				100°F Room	Cycling Room				100°F Room	Cycling Room		100°F Room	Cycling Room	
	A	B	C	D	E	A	B	C	D	E	A	D	E	A	D	E
Appearance	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK
Smell	OK	Off	Off	OK	slightly off	OK	Off	Off	slight poly	OK	stale	stale	OK	OK	OK	OK
Taste "as is"	OK	Off	Off	OK	OK	OK	Off	Off	OK	OK	slightly stale	a	OK	OK	OK	OK
Taste--gruel	OK	Off	Off	OK	OK	OK	-	-	OK	OK	slightly stale	a	OK	OK	OK	OK
Dispersibility in Water	OK	OK	OK	OK	OK	OK	-	-	OK	OK	soggy	white spots	OK	OK	OK	OK
% Water *	5.73	5.93	6.55	5.52	6.13	5.33	6.49	6.36	6.34	5.64	5.74	5.81	5.35	6.09	6.14	5.50
Comments	Good	a	a	Good	bad seal	Good	b	b	Good	Good	fair	poor	good	OK	good	good

a = Picked up odors and taste from cycling room

b = Bad product - picked up odors, taste, and moisture from cycling room

* = Moisture determined by drying 6 hours in a vacuum oven set at 26 inches of vacuum and 70° C.

A = 0.5 mil mylar -0.00035 inch aluminum foil - 3 mil vinyl (polyvinyl chloride) pouch stock
B = Cellophane (Avis Co. RS-2-195 (PS737)
C = 1 mil low density polyethylene (PS691)
D = 0.75 mil capron (nylon-Vicon (saran) dispersion - 2 mil low density polyethylene (PS734)
E = Glass Jar - nitrogen packed

The 100° F Room contains 50% RH and Cycling Room varied from 76°F and 74% RH to 90°F and 78% RH

Table (12)

Thirteen Week Storage Test of Graham Cracker Bar (5)

Test	2 Week					4 Week					8 Week			13 Week		
	100°F Room	Cycling Room				100°F Room	Cycling Room				100°F Room	Cycling Room		100°F Room	Cycling Room	
	A	B	C	D	E	A	B	C	D	E	A	D	E	A	D	E
Appearance	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK
Smell	OK	OK	Off	OK	OK	OK	OK	Off	OK	OK	OK	OK	OK	OK	OK	OK
Taste "as is"	OK	OK	Off	OK	OK	OK	Off	Off	OK	OK	OK	OK	OK	OK	OK	OK
Taste - gruel	OK	OK	OK	OK	OK	OK	-	-	OK	OK	OK	OK	OK	OK	OK	OK
Dispersibility in Water	OK	OK	OK	OK	OK	OK	-	-	OK	OK	OK	too hard	OK	OK	OK	OK
% Water *	2.85	3.98	3.79	4.29	3.78	3.16	5.44	4.50	4.44	3.16	3.00	4.57	3.24	2.87	5.68	3.40
Comments	Good	Good	a	Good	Good	Good	b	b	Good	Good	Good	OK	Good	Good	Good	Good

a = Picked up odors and taste from cycling room.

b = Bad product - picked up odors, taste, and moisture from cycling room.

c = Moisture determined by drying 6 hours in a vacuum oven set at 26 inches of vacuum and 70°C.

A = 0.5 mil mylar -0.00035 inch aluminum foil - 3 mil vinyl (polyvinyl chloride) pouch stock
B = Cellophane (Avis Co. RS-2-195 (PS737)
C = 1 mil low density polyethylene (PS691)
D = 0.75 mil capron (nylon-Vicon (saran) dispersion - 2 mil low density polyethylene (PS734)
E = Glass Jar - nitrogen packed

The 100°F Room contains 50% RH and Cycling Room varied from 76° F and 74% RH to 90°F and 78% RH

From the preceeding data (Tables (8) through (12), it is obvious that the cellophane and low density pouch materials (B & C in the tables) are not adequate to protect the food bars.

XXIII. Storage Studies for Soup Type Bars

The same storage conditions that were used for the cereal type bars as given in Section XXII were used with the following exceptions: 1. The cellophane and low density polyethylene pouches were not used. 2. The nitrogen packed bottles were stored in the freezer. 3. The foil pouch packed bars were stored both in the 100°F room and the cycling room.

Table (13)

Thirteen Week Storage Test of Hash Bar (3) Plus Seasoning Packet

	2 Week				4 Week				8 Week				13 Week			
	100°F Room	Cycling Room		Freezer	100°F Room	Cycling Room		Freezer	100°F Room	Cycling Room		Freezer	100°F Room	Cycling Room		Freezer
est	A	A	B	C	A	A	B	C	A	A	B	C	A	A	B	C
ppearance	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	Darker	OK	OK	OK
mell	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	meaty	OK	OK	OK
'aste "as is"	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK
'aste - gruel	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	b	OK	b	OK
)ispersibility in Water	a	OK	OK	OK	a	OK darker	OK	OK	a	OK	OK	OK	c	OK	OK	OK
% Water in Bar*	7.67	7.14	7.77	7.69	7.71	7.48	7.00	7.87	6.78	6.59	7.58	7.38	7.48	7.43	8.06	7.83
Comments	fair	good	good	fair	good	good	good	good	OK	good	good	good	d	good	OK	good
% Water in* Seasoning	3.77	3.96	3.52	3.83	4.01	3.57	3.63	4.12	3.79	4.01	5.42	3.96	3.87	4.06	7.46	4.00
Seasoning	good	good	good	good	good	good	good	good	OK	OK	OK	good	OK	OK	OK	good

* = Moisture determined by drying 6 hours in a vacuum oven set at 26 inches of vacuum and 70° C.

a = Darker - some white spots
b = Hydrolyzed Vegetable Protein Taste
c = Darker - many white spots
d = Binder did not disperse well

A = 0.5 mil mylar - 0.00035 inch aluminum foil - 3 mil vinyl (polyvinyl chloride) pouch stock.
B = 0.75mil capron (nylon-Vicon (saran) dispersion - 2 mil low density polyethylene (PS734)
C = Glass Jar - nitrogen packed

The 100°F Room contains 50% RH and Cycling Room varied from 76°F and 74% RH to 90°F and 78% RH

Table (14)

Thirteen Week Storage Test of Potato Soup with Beef Bar (3) Plus Seasoning Packet

	2 Week				4 Week				8 Week				13 Week			
	100°F Room	Cycling Room		Freezer	100°F Room	Cycling Room		Freezer	100°F Room	Cycling Room		Freezer	100°F Room	Cycling Room		Freezer
Test	A	A	B	C	A	A	B	C	A	A	B	C	A	A	B	C
Appearance	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	darker	OK	OK	OK
Smell	OK	OK	c	OK	OK	OK	OK	OK	OK	OK	OK	OK	meaty	OK	c	OK
Taste "as is"	OK	OK	d	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	d	OK
Taste - gruel	OK	OK	d	OK	fair	OK	OK	OK	OK	OK	d	OK	fair	OK	d	OK
Dispersibility in Water	OK	OK	OK	OK	a	OK	OK	OK	a	OK	OK	OK	f	OK	OK	OK
% Water in Bar *	7.19	7.00	6.76	7.11	7.36	7.87	6.11	7.45	7.86	7.19	7.21	7.22	7.53	7.56	8.22	7.39
Comments	good	good	e	good	OK	good	good	good	OK	good		good	fair	good	bad	good
% Water in Seasoning*	0.91	0.97	1.33	0.96	1.04	1.04	1.74	0.99	1.04	1.01	3.73	1.03	0.85	1.10	5.65	1.09
Seasoning	good	good	OK	good	good	good	good	good	good	good	moist	good	good	good	moist	good

* = moisture determined by drying 6 hours in a vacuum oven set at 26 inches of vacuum and 70°C.

a = Some white spots
b = Yellow - thin - white spots
c = Slight soapy smell
d = Bad - taste of cycling room
e = Bad seal
f = Some cycling room taste possibly from seasoning packet

A = 0.5 mil mylar - 0.00035 inch aluminum foil - 3 mil vinyl (polyvinyl chloride) pouch stock.
B = 0.75 mil capron (nylon-Vicon (saran) dispersion - 2 mil low density polyethylene (PS734)
C = Glass Jar - nitrogen packed

The 100°F Room contains 50% RH and Cycling Room varied from 76°F and 74% RH to 90°F and 78% RH

DISCUSSION:

The storage studies indicated that if the moisture content of the bars was much above 5%, the binder material would not rehydrate properly when the bars were stored at 100°F. This did not happen in the cycling room where the temperature was not so high. Apparently this lack of ability to rehydrate was associated with the high temperature storage and the higher moisture content. The cereal type bars did not show this with the possible exception of the oat bar. The oat bar did have a moisture content over 5% while the other cereal bars contained less than 5% moisture.

XXIV. Storage Studies of Soup Type Food Bars with Moisture Content Less than 5%

To check whether soup type bars could be stored successfully at 100°F. if their moisture content was reduced to less than 5%, more of the Hash Bar (3) plus seasoning packet and Potato Soup with Beef Bar (3) plus Seasoning Packet were made. The moisture content of these bars was lowered to 4 to 4.5% by drying for 7 hours in an air circulating oven set at 50° C. The six week results of these tests are given in Tables 15 and 16.

Table (15)

Six Weeks Storage Test in Foil Pouches (a) of Hash Bar (3) Plus Seasoning Packet with Moisture Content Less Than 5%

	3 Weeks		4 Weeks		6 Weeks	
Test	100°F Room	Freezer	100°F Room	Freezer	100°F Room	Freezer
Appearance	Good	Good	Good	Good	Good	Good
Smell	Good	Good	Good	Good	Good	Good
Taste -"as is"	Good	Good	Good	Good	Good	Good
Taste - gruel	Good	Good	Good	Good	Good	Good
Dispersibility in Water	Good	Good	Good	Good	Good	Good
% Water*	3.94	-	3.99		4.13	-
Comments	Good	Good	Good	Good	Good	Good

(a) - 0.5 mil mylar -0.00035 inch aluminum foil -3 mil vinyl (polyvinyl chloride) pouch stock

* - Moisture determined by drying 6 hours in a vacuum oven set at 26 inches of vacuum and 70°C.

Table (16)

Six Weeks Storage Test in Foil Pouches (a) of Potato Soup with Beef Bar (3) Plus Seasoning Packet with Moisture Content Less than 5%

	3 Weeks		4 Weeks		6 Weeks	
Test	100°F Room	Freezer	100°F Room	Freezer	100°F Room	Freezer
Appearance	Good	Good	Good	Good	Good	Good
Smell	Good	Good	Good	Good	Good	Good
Taste "as is"	Good	Good	Good	Good	Good	Good
Taste - gruel	Good	Good	Good	Good	Good	Good
Dispersibility in Water	Good	Good	Good	Good	Good	Good
% Water*	4.43	-	4.29	-	4.45	-
Comments	Good	Good	Good	Good	Good	Good

(a) - 0.5 mil mylar -0.00035 inch aluminum foil -3 mil vinyl (polyvinyl chloride) pouch stock.

* - Moisture determined by drying 6 hours in a vacuum oven set at 26 inches of vacuum and 70°C

COMMENTS:

As can be seen by these results, the drying of the bars to less than 5% moisture has prevented the lack of dispersibility of the binders in the bars when stored at 100°F.

XXV. General Conclusions:

Food bars of controlled nutrition, hardness, dispersibility, and stability can be formulated and fabricated by the use of encapsulated fat binder materials. Bars can be made from binder concentrates but superior bars were made with existing equipment using spray dried binders. Low pressures, 250-750 lb./sq. inch were used to form the bars. Bars can be successfully stored in metalized foil pouches at 100°F if moisture content of the bars were below 5%.

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13. ABSTRACT

Formulation, production and storage studies of food bars made from various cereal products (wheat flakes, oats, rice crispies and graham crackers), as well as beef, hash and soup type bars (split pea, potato flakes), are presented. The basic matrix for the food bars is a stable binder formulated from protein (sodium caseinate), fat (lard flakes), and carbohydrate (sucrose). The binder is spray-dried, admixed with the food component, and compressed into bar form.

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