TECHNICAL REPORT
FD-14

ALL-PURPOSE MATRIX FOR MOLDED FOOD BA

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EVANS RESEARCH AND DEVELOPMENT CORPORATION
New York, N. Y.

Contract No. DA 19-129-AMC-2111

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U. S. Army Materiel Command
U. S. ARMY NATICK LABORATORIES
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FOREWORD

In the development of operational feeding systems increased consideration is being given to the logistic advantages of affecting a reduction in food volume corresponding to the decrease in weight achieved by dehydration. Such a reduction in volume becomes a virtual necessity in the design of specialized food packets for the soldier who must carry on his person his entire food supply for extended periods in which resupply is not feasible. Historically the concentrated or compacted foods in the military supply system have been restricted to confectionary items, compressed cereals and one ground, air dried meat bar of marginal acceptability.

In theory, any food which is sufficiently dry to be stable can be fabricated into compact bars. This concept can be extended to the development of more sophisticated bars which are not only acceptable for direct consumption but are also susceptible to hydration to yield familiar food items. For example, a cream soup bar, a beef stew bar or a chocolate pudding bar may be designed both for direct consumption or for rehydration to a common meal item of greater acceptability. As a working hypothesis it is assumed that suitable bars can be prepared either by compressing or molding certain dry foods. Extension of these techniques to the preparation of suitable bars from virtually all dry foods is presumed to require the incorporation of special components to insure proper cohesion and other essential properties. This investigation seeks the development and demonstration of one or more edible components which insure the preparation of a great variety of molded food bars to be consumed both dry and after rehydration.

The investigation described in this report was conducted by the Evans Research and Development Corporation, 250 East 43rd Street, New York 10017, under contract number DA19-129-AMC-2111. Dr. E. J. Hewitt served as Official Investigator. His collaborators were Mr. T. A. Smith, Mr. P. Mech, Mr. R. Groncki, Dr. F. del Valle, and Mr. J. Zolotar.

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ABSTRACT

The object of the program was to produce a suitable matrix for various food components (soups, beverages, and casseroles) which would not detract from the basic flavor of the major food component. A satisfactory matrix was made from lactose (99%) and sodium carboxymethylcellulose (1%). The matrix can be produced successfully by tray-drying or freeze-drying. This report summarizes the work performed in Phase I and Phase II of the contract and gives the results of the various shelf-life tests. In general, the lactose/carboxymethylcellulose matrix performed well over the broad range of products that were tested.

INTRODUCTION

On September 17, 1962 Evans Research and Development Corporation was authorized by the Armed Forces Food and Container Institute of the U. S. Army Quartermaster Research and Engineering Center, Natick, Massachusetts, to initiate work on an all-purpose matrix for molded food bars capable of binding various types of food material.

The objective of the program was to develop two matrices: one matrix (Composition C) was to bind dehydrated solid foods, for example, beef stew, lemon cream puddings and chicken and rice. The second matrix (Composition D) was to be utilized in soups and beverages. If possible, the development of a single matrix to serve both food groups would be highly desirable.

The matrix developed should not impart any flavor foreign to the food ingredient being molded. The food bar should have an acceptable odor and flavor characteristic of the primary composition. In addition to the above specifications, all food bars should conform with detailed specification as listed in the contract.

SUMMARY

An all-purpose matrix was developed to be used as a base for compressed food bars. These food bars are prepared with a food component such as beef stew, soup, pudding and beverage. The preparation of the food bars involved simply the mixing of the matrix with the dehydrated food and subsequent molding with pressure into bars. The all-purpose matrix (Matrix Formula No. 18) consists of lactose and sodium carboxymethylcellulose.

Matrix No. 18 was found to be an adequate binder for all types of food products in the contract and to satisfy all the specifications for an edible-type binder for food materials. In general, Matrix No. 18 produced food bars which passed all requirements in the shelf-life tests.

The only food bars which were below contract specifications were the pudding bars due to hardness and orange bars due to hydroscopicity. In both instances these defects were caused by the very nature of the food component.

Matrix No. 18 can be readily made by tray-drying or freeze-drying. Although tray-drying and freeze-drying were proven to be satisfactory, there may be economic reasons for the preparation of the matrix by spray-drying. Some encouraging results were obtained in spray-drying, but additional work is necessary to improve the matrix by this method.

EXPERIMENTAL DISCUSSION

I. SCREENING OF MATRIX INGREDIENTS

Evans Research obtained samples of basic foodstuffs and pertinent information regarding binding qualities, nutritional and stability data from various suppliers. More than seventy samples were received and evaluated as constituents for Compositions C and D. Table I lists these by major nutritional category and supplier.

The materials were screened for bland flavor by an informal panel. In addition, the physical binding and adhesive properties of many of the ingredients were examined in trial formulations. Based upon the results of the screening program, prototype formulations were prepared and studied.

Given below is a summary of results of the screening program to identify ingredients that would be suitable for Composition C and D matrices.

A. Proteins

These ingredients included: (1) dairy derivatives, such as nonfat dry milk solids, caseinates, and lactalbumin; (2) soy products; (3) gelatins; (4) glutins; (5) yeasts.

Of all ingredients evaluated, Promine D (soy product) was best suited for Composition C and D requirements. Promine D has a bland flavor, good water-absorbent properties, and good binding properties. This ingredient was finally selected for the intermediate and final formulas which will be discussed later.

B. Carbohydrates

Rice, barley and oatmeal baby cereals were examined as they represented a bland source of carbohydrate with good binding and adhesive properties. All three of the cereals were found to be interchangeable in the preliminary formulas.

Other carbohydrate materials such as confectionery, brown, and granulated sugar, molasses, corn syrup, and honey, all-purpose, oat and potato flour, lactose; and Clearjel starc were all tested and found to contribute to the adhesive and binding nature of the matrix. The confectionery and granulated sugar, corn syrup, Clearjel starch, and Lactose provided no additional flavor characteristics and were judged to be acceptable carbohydrate sources.

Granulated sugar and lactose, in these preliminary tests showed the most promise.

C. Fats

Hydrogenated shortening due to its lack of greasy aftertaste, bland flavor, good mixing properties, high melting point and stability has been used in all formulations requiring fat.

Spray-dried fats were evaluated, but were not utilized as their particular free-flowing properties apparently would not be required.

D. Gums and Modified Starches

Based upon the screening evaluation, almost all of the natural gums and synthetic polymers tested have proved to be quite effective as binding and adhesive aids in the matrix formulation.

In preliminary work it was not known how important the use of these types of materials would be in Compositions C and D. As discussed later, carboxymethylcellulose was chosen as a main ingredient for the general purpose matrix (Formula No. 18).

II. TESTING OF PRELIMINARY FORMULAS FOR COMPOSITION C PRODUCTS

A. Selection of Formula No.7

The materials which passed the initial screening were compounded into matrix formulations. The mixing procedure followed for blending the matrix for Compositions C and D is as follows:

All readily soluble dry ingredients were dry-blended together using a Hobart mixer. Ingredients such as gums or gelatin were first dispersed in minimum amounts of water and the above components added and mixed until the adhesive properties of the matrix were developed. The food components were added and blended and the entire mixture was cast into molds and allowed to set up at room temperature. At this point the food components used for these evaluations were ground crackers and cookies.

It was found that Elvanol* (polyvinyl alcohol) improved the molding and handling properties of the formula.

Also gelatin and Clearjel starch, when used in combination with Elvanol, gave additional improvements.

Formula 7 (given below) was described as the most satisfactory prototype for Composition C. However, it was believed that systematic modification of the basic Formula 7 would yield an improved bar matrix.

FORMULA NO. 7

Ingredient	% By Weight
Hydrogenated vegetable shortening	4.00
Promine D (Clarified)	1.20
Sugar, granulated	4.00
Gelatin XXX	0.20
Clearjel starch	0.40
Elvanol 50-42 (PVA)	0.20
Water	10.00
Green Pea Soup, dehydrated**	80.00

B. Examination and Modification of Formula No. 7

1. Hydrogenated Vegetable Shortening

The major source of fat in Formula 7 was hydrogenated vegetable shortening, accounting for 41 percent of the matrix

*While permissible in pharmaceutical products, polyvinyl alcohol is not permitted in foods but was used to serve as an example of an effective binding agent.

**Added component.

on a dry basis. To determine the effect of different fat levels, the percentage of fat in Formula 7 was increased and decreased in 5 percent increments.

As the fat level decreased, the bar samples became more crumbly. As the fat level increased, the composition became more plastic and could not withstand pressure or molding. On the basis of these tests the fat level was left at 41 percent.

2. Promine D

The increment approach was taken in determining the effect of Promine D level in Formula 7 (1.20%). It was found that an increase of Promine D bound the water excessively and produced a distinct crumbling effect in the bar. On the other hand, a decrease in the quantity of Promine D did not adversely affect the binding characteristics of the bar until the level went below 0.40 percent. The complete removal of Promine D produced an unsatisfactory bar. On the basis of this work, the Promine D level was reduced from 1.20 percent to 0.40 percent.

3. Granulated Sugar

Granulated sugar was the next item critically examined. It was found that the original 4.00 percent quantity of sugar was necessary. However, substitution of 50 percent of the granulated sucrose with confectioner's sugar had a beneficial effect on the formulation. Apparently, the small amount of starch present in the 10X sugar aided in the dispersion of the Promine D and the Clearjel starch.

4. Clearjel Starch

In evaluating the use levels of Clearjel starch, it was found that a 50 percent reduction produced an acceptable product. The complete removal of Clearjel destroyed the binding qualities of the matrix and produced a bar with little or no resistance to pressure. The Clearjel, when increased beyond 0.48 percent of the bar formula, began to introduce a crumbling effect. On the basis of these tests, the Clearjel was left at its initial level of 0.40 percent.

5. Polyvinyl Alcohol

The Elvanol 50-42 or polyvinyl alcohol content of Formula 7 (0.20%) was altered in increments. Lower levels produced a food bar which was structurally weak and slightly sticky. Complete removal of the Elvanol destroyed the matrix. By increasing the quantity of Elvanol, a stronger bar, physically superior to the original Formula 7 was produced. The best or most efficient level was found to be 0.40 percent.

6. Gelatin

Gelatin was originally incorporated in Formula 7 for its bland flavor, binding properties and film-forming characteristics. However, a slight stickiness was noted with its use.

In these modification studies of Formula 7, a satisfactory substitute for Elvanol was not found. Additionally, the increase in polyvinyl alcohol content functioned similarly to the gelatin. Consequently, the gelatin fraction of the food bar was eliminated with a physically superior bar as the result.

7. Screening of Protein Sources

A low-flavor sodium caseinate (Sheffield Chemical Co.) was investigated as a protein source both for its nutritional amino acid balance and its emulsifying and water-binding properties. The substitution of Promine D with sodium caseinate produced a food bar with a crumbling effect.

Edi-Pro A and N, soy protein fractions manufactured by the Ralston Purina Co., were also examined. No significant advantage over the use of Promine D could be found.

The net result of these modifications was Formula 14, given below. The over-all composition and nutritional breakdown is given Tables II and III.

FORMULA NO.14

Ingredient	% By Weight
Hydrogenated vegetable shortening	4.00
Promine D (Clarified)	0.40
Sugar, granulated	2.00
Sugar, 10X	2.00
Clearjel Starch	0.40
Elvanol 50-42 (PVA)	0.40
Water	10.00
Food material*	80.80

C. Evaluation of Formula No.14

The following food components were tested with Formula 14 as Composition C.

FOOD	Precooked Tapioca Graham Crackers Cookies, 5-10% moisture Pie Crust, 10% moisture Dry Peaches, 18% moisture Peanuts Freeze-Dried Cooked Chicken Prefried Bacon Sweet Chocolate Dried Dates, 20% moisture Fruit Preserves, 20% moisture Gouda Cheese or Equivalent Precooked Freeze-Dried Scrambled Eggs Dry Fish (cooked)
SOUP	Split Pea Cream of Mushroom Shrimp Chowder Chicken Beef
BEVERAGE	Coffee Tea Milk (nonfat) Cocoa Orange Crystals Buttermilk

*Added component.

The food bars were prepared with Formula 14 by first blending the matrix components until its adhesive properties were developed. Then the food component was added and blended. The bars were hand-molded and allowed to set up at room temperature. Of the food components tested, only the scrambled eggs, cheese, and dry fish failed to combine successfully with Formula 14.

Informal sensory examination indicated that the food bars produced were acceptable in both odor and taste.

Only one problem was encountered; an oil slick was observed to form on the surface of the bar prepared with roasted peanuts. Pretreatment of the peanuts before incorporation overcame this condition.

The food bars prepared with Formula 14 were screened informally for compliance with the physical requirements of the contract. All of the bars were easily sheared by incisors and chewable. They did not shatter when dropped from a height of 6 feet onto a concrete floor. They did not become sticky.

The food bars were screened for dimensional stability. The results were satisfactory as the bars withstood 5 pound pressure per square inch for 24 hours at 120°F. They were also satisfactory after exposure to the same pressure at 75°F for a full week.

III. TESTING OF PRELIMINARY FORMULAS FOR COMPOSITION D PRODUCTS

As per contract specifications, Composition D was to be developed as a base for soup and beverage bars. These bars should be suitable for consumption as bars or dispersible in water to yield an acceptable soup or beverage.

In the selection of a binding agent for use in Composition D, corn syrup, molasses, and brown sugar had satisfactory physical properties, but molasses and brown sugar gave rise to detectable flavors in food bar compositions. Corn syrup was thus given further examination as a binding agent.

Inducing a very slow rate of rehydration, the less dispersible rice cereal and Promine D were replaced by a greatly increased percentage of nonfat dry milk solids.

The initial attempts to formulate Composition D were generally unsuccessful due to slow rates of rehydration. As a result, a completely new approach was taken. The approach was to screen only those ingredients which are readily cold-water soluble.

The first combinations examined were blends of sucrose or invert sugar with cold-water soluble gums. The use of 99 percent sucrose or invert with 1 percent polyvinyl alcohol (Elvanol 50-42) was found to give physically satisfactory Composition D prototypes. The over-all composition and nutritional breakdown are listed in Tables II and III.

The formulas were prepared by dissolving 99 grams of pure sucrose in a quantity of water containing 1 gram of PVA. The resultant mixture was freeze-dried. The product was a dry, crystalline powder with a rapid rehydration rate. The dry sucrose and PVA mixture was blended with soup and beverage ingredients, to which a small quantity of water had been added. The mixture was heated at 212°F for 60 minutes and hand molded into bars.

The general physical characteristics of the formulated bars were good. They dissolved slowly in room temperature water but, in view of past problems in obtaining rehydration, this work was significant. Dispersing and disintegrating aids were next examined in order to increase rehydration rates.

The soup ingredients examined were dehydrated green pea soup and dehydrated chicken soup. The beverages examined were nonfat dry milk and orange crystals. Any possible flavors contributed by the presence of sucrose or invert in the base composition were judged informally to have been masked by the major food ingredient.

The food bars produced were informally screened for physical characteristics. All of the formulations were judged acceptable for shearability, chewability, shatter resistance, dimensional stability and stickiness.

Composition D was basically designed to take advantage of the film-forming and adhesive qualities of sucrose and polyvinyl alcohol. Composition D also successfully bound graham crackers, freeze-dried chicken, and dried dates into food bars.

The evidence began to point to the fact that a prototype had been developed which could effectively make food bars for the majority of foods listed under both Compositions C and D. At the same time, it would be advantageous to reduce the sweetness level of the matrix and find substitutes for polyvinyl alcohol. The following experiments were conducted in an effort to produce a general purpose matrix for both Compositions C and D.

IV. DEVELOPMENT OF GENERAL PURPOSE MATRIX FORMULA NO.18

A. Evaluation of Carbohydrates and Final Selection of Lactose

Carbohydrates were tested separately in combination with a single polymer, namely sodium carboxymethylcellulose. The items tested as the major carbohydrate portion of the matrix were sucrose, dextrose, lactose, modified starches, unmodified starches, starch fractions, invert syrup, dextrans and dextrins. Since the dextrans and dextrins can be classified as both carbohydrates and polymers, they were tested separately under the two groups, i.e., as polymers they replace sodium carboxymethylcellulose at the 1 percent level and as carbohydrates they replace sucrose at the 99 percent level. (Table IV)

The methods for forming the first set of food bars with the above mentioned components is described in Table V. The following results were obtained:

1. Of all the carbohydrates, sucrose, dextrose and lactose made the best food bars with sodium carboxymethylcellulose.

2. The modified and regular starches, the dextrans and dextrins were unsatisfactory due either to (a) the flavor they imparted to the food component or (b) slow rehydration rates.

3. Based upon organoleptic evaluations of the sucrose, dextrose and lactose matrices, the lactose was preferred for its lower sweetness level.

B. Evaluation of Polymers and Final Selection of CMC

The next step was the addition of a series of polymers in place of sodium carboxymethylcellulose. Polyvinylpyrrolidone, methylcellulose, hydroxyethylcellulose, dextrins, dextrans, cellulose acetate phthalate, dialdehyde starches, polyvinyl alcohol and a mixture of the ethers of methylcellulose and hydroxypropylmethylcellulose were substituted for sodium carboxymethylcellulose at 1 percent levels. The results of the tests are as follows:

1. Food bars made with cellulose acetate phthalate, dextrans, dextrins, and dialdehyde starches displayed physical properties inferior to those bars made with sodium carboxymethylcellulose.

2. Polyvinyl alcohol, polyvinylpyrrolidone, methylcellulose, hydroxyethylcellulose, and ethers of methylcellulose and hydroxypropylmethylcellulose formed bars which were equal to sodium carboxymethylcellulose in binding power and other physical properties. (Several of the cellulose polymers gave viscous solutions in beverages but this effect could be reduced by lowering the actual quantity of the matrix required to bind the foods.)

As a result of the above tests, sodium carboxymethylcellulose was chosen for the adhesive agent in the general purpose matrix Formula No. 18 given in the following section.

C. Matrix Formula No. 18

Several general purpose matrix formulations reported were evaluated for over-all conformance to the specifications of the contract. The best formula in this series was Formula No. 18 given below:

Ingredient	% By Weight
Lactose	99
Sodium carboxymethylcellulose (CMC)	1

Formula No. 18 was preferred mainly because of its lack of taste. Furthermore, CMC is reported to be recognized as safe by the U.S. Food and Drug Administration for use in food products.* The many other polymers which were considered in the earlier stages of the program were used mainly to illustrate the plausibility of putting a film-forming compound (a polymer) in the matrix to improve its binding properties. Formula No.18 was prepared as indicated in the four steps below:

1. 99 grams of lactose were dissolved in 500 ml of water.

2. 1 gram of NaCMC was dissolved in 100 ml of water.

3. 1 and 2 were mixed and brought to a volume of 1000 ml.

4. The mixture was freeze-dried. A fluffy powder was obtained.

The same laboratory procedure was used in the preparation of Formula No.18 for all food, soup and beverage bars. Initially, all the matrices used in the preparation of these food bars were freeze-dried. Later, experiments were conducted with spray-dried and tray-dried matrices.

V. PROCESSING AND MOLDING OF FOOD BARS

A. Combining the Matrix with a Food, Soup, or Beverage Component

Eighteen of the 25 food, beverage, or soup components specified in the contract were incorporated individually with all purpose matrix No.18 and compressed into food bars for experimental purposes and storage stability studies.

Initially the molding of the food bars was performed by hand with minimum amounts of pressure. The molding process used during the last quarter involved the application of pressure to "slugs" or preweighed quantities of matrix and food component mixtures. Experimentally, it has been

*21 Code of Federal Regulations Section 121.101.

found that the variation of pressure in the mold (up to 5000 psi) can produce bars with considerable fluctuation in physical properties. The consistency of food bars can be made to vary from soft to very hard.

Each food component presents different problems in density and pressure requirements, but the judicious use of pressure control and sample weight will produce acceptable, good bars.

Table VI gives the types and composition of the food bars made, Table VII describes the method of packaging the bars, and Table VIII gives the number and storage conditions of the bars set aside for storage stability studies.

The general laboratory procedure used in the preparation and packaging of these food bars is as follows:

Eighty grams of the component selected and 20 grams of matrix are stirred mechanically in a mixing bowl for 5 minutes. The liquid portion (glycerine) is then added and the mixture stirred for 5 minutes more. If a soup or beverage bar is to be made, the sodium bicarbonate and fumaric acid are then added.

The laboratory procedure used for mixing the matrix with food, soup or beverage components was satisfactory and could be adapted to large scale operations. The essential ingredients in each bar are the matrix and the food, soup, or beverage component. Other components such as glycerine are required in all cases to facilitate mixing and to activate the matrix so it will cement the dry particles of food, soup, or beverage component. The amount of glycerine required, which depends on the type of component being added, is shown in Table VI.

Certain modifications of the procedure are necessary when certain of the food, soup, or beverage components are added to the base mix. The use of instant coffee offered a problem in that the bar is hygroscopic. The dry mixing of coffee and matrix offered no serious problem if the room moisture was kept at 20 percent relative humidity.

When bacon, pie crust, and other greasy foods were added to the base mix it was necessary to freeze the food before it was added to the base mix.

The moisture content of peanuts varies widely according to the type used. The water content of the base mix, therefore, had to be regulated, so that the total water content of the bar was such that the cementing action of the matrix was maintained at a high level.

When dry milk powder was incorporated in a food bar, it was necessary to add a small amount of diglyceride to facilitate dispersion of the milk powder in rehydration.

When a chocolate flavored bar is made, it is advisable, from the standpoint of stability, to use a high grade of chocolate, preferably the type recommended for use in tropical climates.

The food bars for the various tests were prepared by compression molding in a laboratory Carver Press using a mold that produced a tablet 1-1/4 inches in diameter and 3/8 inch thick. The dial reading on the press mold was set at 4000 pounds per square inch. Commercial compression molding techniques may be adequate for the molding procedure.

B. Packaging of the Food Bar

Five tablets were placed in a metalized polyethylene pouch and the opening was heat-sealed. Six pouches of each flavor were made and placed under storage. Table VII describes the method of packaging the bars and Table VIII gives the number and storage conditions of the bars set aside for storage stability studies.

VI. ALTERNATE METHODS FOR PREPARING MATRIX NO.18

Matrix No.18 was successfully prepared originally by means of freeze-drying. However, due to the high cost of freeze-drying, alternate methods of drying were tested, in an effort to develop a less expensive production procedure. Spray-drying, tray-drying, and dry-mixing were selected as alternate methods for evaluation.

Graham cracker and cream of mushroom soup bars were used as representative materials in an initial comparison of the four methods of preparation of the matrix. The two types of food products were combined with the matrices prepared by the various drying procedures according to the formulas given in Tables XI and XII. The food components were first passed through a U.S. Sieve No.10 and the matrix through a U.S. Sieve No.60.

Two hundred grams of the food component and 28 grams of matrix were stirred mechanically in a mixing bowl for five minutes. Eight grams of glycerine was then added and the mixture stirred for five minutes more. In the case of the cream of mushroom soup bar, the sodium bicarbonate and fumaric acid were then added.

A. Test of Alternate Drying Procedures

Ninety-nine grams of lactose were dissolved in 500 ml of water. One gram of sodium carboxymethylcellulose (food grade) was dissolved in 100 ml of water. The two solutions were mixed and diluted with water to 1000 ml. The resulting solution was then freeze-dried, yielding a fluffy powder.

1. Freeze-Drying

The bars made with freeze-dried matrix were compression molded in a laboratory Carver Press at 4000 pounds per square inch; those made with mushroom soup at 4200 pounds per square inch.

2. Spray-Drying

A Bowen Laboratory Spray-Drier with a gas-fired burner was used to spray-dry the matrix. A series of runs, described in Table XIII, was made to determine optimum operating conditions to prepare a satisfactory dry powder as matrix material. Concentration of solids in the feed solution was varied from 6 to 30 percent; inlet temperatures from 450 to 700°F; outlet temperature from 140 to 200°F; and flow-rate from 50 to 120 ml per minute at 48000 rpm atomizer speed.

Optimum spray-drying was obtained at a solids concentration of 15 percent in the feed solution, a feed rate of

110 ml per minute, an atomizer speed of 48000 rpm; an inlet temperature of 650°F, and an outlet temperature of 170°F. The final moisture content of the powder obtained under these conditions was 1.2 percent. (Table XIII)

Bars made with spray-dried matrix were compressed in the same manner as for the freeze-dried matrix.

3. Tray-Drying

It was decided to conduct experiments on the forced air tray-drying of this mixture to determine if this method would produce a satisfactory matrix.

Five different samples of Matrix No.18 were prepared using varying amounts of water. The preparation and conditions for drying of these samples are described below and summarized in Table XIV.

1. A solution containing 168.3 grams of lactose, 1.7 grams of CMC, and 828.3 grams of water was made and dried at 190°F for 5 hours.

2. A more concentrated solution using 495 grams of lactose and 5 grams of CMC was made using 500 grams of water in order to increase the efficiency of drying the matrix. This solution was dried at 190°F for 5 hours.

3. A paste was prepared by dissolving 1.7 grams of CMC in 65 grams of water and blending the mixture with 168.3 grams of the dry lactose until a paste-like texture was obtained. The material was then placed on a tray, spread out with a spatula, and dried at 190°F for 3 hours.

4. A granulation was prepared by dissolving 1.7 grams of CMC in 30 grams of water and slowly adding the resulting solution to 168.3 grams of lactose. The granulation was dried at 190°F for approximately 3 hours.

5. Controls were prepared consisting of spray-dried lactose both alone and physically mixed with CMC. No water was added.

After the samples were dried, they were passed through a No.60 mesh sieve and were incorporated and compressed into cream of mushroom soup and graham cracker food bars. The dried cream of mushroom soup and graham cracker components had previously been passed through a No.10 mesh sieve. The ingredients of the food bars are listed in Table XV.

4. Dry-Mixing

Experiments were run also to determine whether satisfactory bars could be made by dry-mixing the food component with the individual components of Matrix No.18, namely spray-dried lactose USP and CMC. Food bars were made of graham crackers and glycerine, graham crackers with lactose and glycerine, and graham crackers with glycerine and CMC according to the formulas listed in Table XVI. The experiment was repeated using dehydrated cream of mushroom soup to which the usual sodium bicarbonate and fumaric acid mixture was added.

B. Evaluation of Bars by Physical Testing

The molded food bars were then compared using six-foot drop tests and penetration tests to determine whether the method of drying the matrix could be varied without impairment of the physical characteristics of the bar.

1. Results of Six-Foot Drop Test

The bars made with freeze-dried matrix all passed the six-foot drop test.

The food bars made with graham crackers and the spray-dried matrix lacked the physical characteristics specified in the contract. The bars were soft and crumbly and broke when dropped onto a concrete floor from a height of 6 feet.

The use of tray-dried matrices produced by means of procedures Nos. 1 and 2 (see page 17) resulted in the production of graham cracker and mushroom soup bars which withstood the six-foot drop test. The best food bar was produced using 50 grams of No.2 and 2 grams of glycerine. The bars produced using Nos.3 and 4 were weaker than those made with Nos.1 and 2, while those made with No.5 were unsatisfactory. On the basis of the above experiment, it was decided to use procedure No.2 for the tray-drying of Matrix No.18.

The dry-mixed food bars were rated as inferior in physical tests and in appearance to food bars made with freeze-dried matrix, spray-dried matrix, or tray-dried matrix.

2. Results of Penetration Tests

Penetration readings were taken with a 1200F Penetrometer* to obtain objective measurements of the hardness of the graham cracker food bars made with the four types of matrices tested. The formulas of the bars are given in Tables XVI and XVII. Such measurements also allow the tester to determine the varying degrees of hardness and/or brittleness of the food bar more accurately than can be determined in the six-foot drop test.

The penetrometer was adjusted to allow the pointed cone to drop two inches before hitting the food bar and to use the surface of the food bar as a zero point so that penetration would be expressed as the difference between the zero point and the cone after impact. The readings were taken in hundredths of a millimeter. The smaller the reading, the greater the resistance to the pointed cone on impact; therefore, the smaller readings indicate a harder or more rigid bar. Ten readings were taken, each on a separate food bar. Table XVIII summarizes the results of the tests.

The average penetration values obtained for the matrices indicated that the tray-dried matrix formed a hard food bar. The freeze-dried matrix formed a slightly softer bar but was still very acceptable for food bar production.

The spray-dried binder produces too crumbly a bar with a penetration value of 240.5. For practical purposes the spray-dried matrix did not produce an acceptable food bar. The graham crackers alone when compressed give a bar with a penetration reading of 233.5. The use of unprocessed lactose (spray-dried USP) and unprocessed CMC also

*Supplied by the Arthur H. Thomas Company.

results in bars with penetration properties superior to those obtained for the spray-dried matrix.

It has been noted that some of the food bars made with unprocessed matrix were quite grainy and brittle. They cannot undergo repeated drop tests as can bars made from the freeze-dried and tray-dried matrices. The microscopic dispersion of the CMC particles on the lactose in the freeze-dried and tray-dried matrices undoubtedly lends itself readily to instant activation, while the large surface area of these particles provides good interlocking during compression. The resultant products are hard but more readily plastic in nature than the brittle, spray-dried food bars.

The results of the above tests supported the decision to drop work on dry-mixing of the matrix and further indicated that a matrix produced by either tray-drying or freeze-drying would be acceptable for food bars.

C. Additional Tests with Other Food Components

1. Preparation of Bars

The preliminary evaluation of the efficiency of matrices dried by freeze-drying, spray-drying, and tray-drying was performed using only graham crackers and mushroom soup. The procedure, as explained previously, was convenient and time-saving. However, in accordance with the contract, the scope of the evaluation was subsequently widened.

Representative samples of the foods listed in Phase II were selected and mixed with the dried samples of matrix according to the formulas given in Table XIX. The foods selected were orange juice, cream of mushroom soup, chicken noodle soup, and chocolate pudding. Bars of these foods were formed in a Carver Press at 500 psi. Six-foot drop tests as well as organoleptic, penetration, and dispersion tests were then performed on these bars.

2. Results of Tests

a. Six-Foot Drop Tests

All bars tested passed the six-foot drop test. However, in this respect, the bars containing spray-dried matrix were found to be inferior to the freeze-dried and tray-dried food bars, barely passing the six-foot drop test.

b. Penetration Tests

Penetration tests were run on the bars using the penetrometer and technique described above. The results of the tests are summarized in Table XX.

The bars produced with tray-dried matrix sustained the lowest amount of penetration in three out of four products, those made with spray-dried matrix gave the second lowest amount for all products, while those made with freeze-dried matrix gave the highest penetration in three cases and the lowest in one.

c. Organoleptic Tests

The hedonic ratings given the food bars tested are summarized in Table XXI. The results indicate that an hedonically acceptable bar is produced from any of the matrices tested. However, the bar made with the spray-dried binder was rated as grainy.

d. Dispersion Tests

The solubility or ease of dispersion of the food bars produced using the freeze-dried, spray-dried and tray-dried matrices was evaluated and the results summarized in Table XXII.

A 400 ml beaker containing 200 ml of water at room temperature was placed on a magnetic stirrer, the magnetic bar was placed in the beaker, and the rate of stirring standardized. An unbroken food bar was placed in the beaker. The food bar was not broken by the stirrer bar, since the stirrer produced a current or flow of water but made no contact with the food bar. The time for the entire food bar to go into solution was recorded.

The results of the tests indicate that there was no significant difference in the dispersion time for the pudding or orange food bars made with the three types of matrix.

However, when the bars made from the two soups (cream of mushroom and chicken noodle) were dissolved, those made from the tray-dried binder dissolved appreciably faster than those made with the freeze-dried. There was only a slight difference between soup bars made with spray-dried matrix and those made with the tray-dried matrix.

3. General Conclusions of Tests

The above tests confirmed that the spray-dried matrix produced bars which dissolved readily but generally gave the smallest penetration. This bar cannot withstand shock or excessive strain. The spray-dried binder results in a bar which has an apparent lack of physical strength, but which disintegrates readily in water because of the highly smooth, hard surface of the particles of the matrix.

D. Microscopic Examination of Matrices and Food Bars

Photomicrographs were taken of freeze-dried, spray-dried, and tray-dried matrix surfaces as well as of the surfaces of the bars made from these matrixes in an effort to determine whether there is any connection between surface characteristics and physical properties.

1. Matrix Surface Characteristics

Photomicrographs of freeze-dried, tray-dried, and spray-dried matrices are shown in Figures 1, 2, and 3, respectively, at a magnification of 131X.

The large crystalline surface area of the freeze-dried matrix explains its ability to compress easily and bind effectively. It has almost instant solubility compared to the other processed matrices.

The tray-dried matrix has a highly irregular, large, surface area which permits it to bind effectively and allows rapid dispersion of the food bar in water. It is in itself not as rapidly soluble as the freeze-dried matrix but will permit the food bar produced with it to be dispersed readily.

The spray-dried matrix particles have a highly smooth, small, surface area. Therefore, unlike the tray-dried and freeze-dried matrices, this matrix has no ability to interlock; however, by nature, such a bar would disintegrate readily in water.

In general, the photomicrographs reproduced in Figures 1, 2, and 3 illustrate why the experimental food bars made with freeze-dried and tray-dried matrices would possess good physical properties.

2. Food Bar Surface Characteristics

Photomicrographs of the surface of bars made from freeze-dried, spray-dried, and tray-dried matrices are shown in Figures 4, 5, and 6, respectively, at a magnification of 39X.

In general, the most uniform dispersion of matrix-food is found in the freeze-dried sample and the second most uniform in the tray-dried sample. Both the freeze-dried and tray-dried surfaces are regular and smooth. In contrast, the bar made with spray-dried matrix has an irregular surface and lacks a uniform appearance.

A study was undertaken to improve the quality of the spray-dried matrix with Formula No.18. This was considered a worthwhile objective because of general availability of spray-drying equipment in commercial operations.

VII. IMPROVEMENT OF MATRIX NO.18 BY SPRAY-DRYING IN COMMERCIAL EQUIPMENT

A. Background on Laboratory Spray-Dried Matrix

Spray-dried Matrix No.18 produced bars which dissolved readily but generally gave the poorest penetration test results. The spray-dried bars were brittle and could not withstand excessive strain or shock.

The highest percentage of solids used was 30 percent with operating temperatures of 500°F at the inlet and 185°F at the outlet. It was found that the greater the percentage of solids, the more satisfactory the results, probably because the crystals formed are larger and more irregular.

With the available equipment, the solids content could not be increased readily above 30 percent. In addition it was surmised that the use of a nozzle-type spray-drying head would give more irregular-type particles, much like those of the lactose used in tabletting operations.

To obtain a spray-dried mixture of lactose and carboxymethylcellulose which would increase resistance to breakage and decrease solubility time in food bars, Evans Research asked Foremost Dairies to use their equipment to spray-dry a special sample of 200 pounds of lactose/carboxymethylcellulose.

B. Commercial Spray-Drying of Matrix

Two hundred pounds of lactose/CMC was prepared by Foremost Dairies. Evans Research supplied 2 pounds of low viscosity food grade carboxymethylcellulose in solution with 0.05 percent methylparaben used as a preservative. Foremost Dairies added this solution to their slurry of 198 pounds of lactose. It had been requested that the slurry be spray-dried with a nozzle or by whatever procedure normally used by Foremost Dairies to produce their tabletting-grade lactose or instant-type dry milk. A photomicrograph of the lactose spr. dried by Foremost Dairies is shown in Figure 7.

On delivery of the spray-dried material, a series of penetration and solubility tests were immediately carried out on food bars made from the new material. The results are presented in Table XXV and indicate that the material produced by Foremost Dairies was considerably more dispersibl in water and forms a harder, less brittle bar which can meet the specifications of the 6-foot drop test.

At this point, it appeared that the spray-dried matrix would be preferable to the tray-dried in beverage and soup components. However, additional tests had to be conducted before the improved spray-dried matrix could be considered acceptable.

C. Formula-Variation Experiments with Spray-Dried Matrix No. 18

In addition to the above experiments with commercially prepared spray-dried materials, Evans Research conducted other spray-drying experiments with variations of the original formula of Matrix No. 18.

The following three variations in the formula of Matrix No. 18 were prepared: (a) 50 percent sodium caseinate was added; (b) maltodextrin was substituted for lactose and 1 percent glycerine was added; and (c) 1 percent glycerine was added.

In the first variation, the bars made did not pass the 6-foot drop test. The effect of the casein was to increase the adhesiveness of the matrix and add an off-taste.

In the second, the maltodextrin matrix had better solubility, but the bars produced had a pasty taste.

Finally, the addition of 1 percent glycerine to Matrix No. 18 appeared to slightly improve the binding properties of the spray-dried matrix. The validity of this result would have to be evaluated by additional tests. The results did not warrant further consideration of these variations.

VIII. EFFECTS OF FAT ON MATRIX NO. 18

Matrix No. 18 can readily be affected by liquid-type fat. In order to increase the caloric value of some food bars to the desired level by the addition of fats, it was necessary to employ a type of fat that would not affect the stability of the food bar. However, when one part of cottonseed oil is added to one part of matrix, a very weak bar is produced, and the only solution was found to lie in the use of fully hydrogenated fats with high melting points or specific fractions such as cottonseed stearin or coated plastic fats.

It was found that the use of a high-melting-point plastic fat permitted the food bar to meet contract specifications for stability. A specific procedure, however, had to be followed in producing the bar.

1. The fat is coated with the food component.

2. After a blending operation similar to those used in the cake industry. the dried matrix is added.

3. Glycerine is added to activate the matrix.

4. The mixture is thoroughly blended.

5. The blended mixture is compressed into food bars using the procedure described earlier.

The bars produced by the above procedure are quite acceptable, but the results of penetration and other stability tests are not quite so good as those obtained with bars containing no fat. This effect, however, had been anticipated. The penetration values for food bars made with equal amounts of fat and matrix are listed in Table XXVI. In general, the bar is more plastic, or soft, with the additional fat content.

IX. CALORIC VALUES OF FOOD BARS

In Table XXVII are listed the caloric values of the 20 food bars on an avoirdupois ounce bases. All the bars satisfy the caloric requirements. The formulae for the new orange juice, tomato juice, and apricot nectar which did not meet the caloric values previously are listed in Table XXVIII.

X. SHELF-LIFE TESTS ON FOOD BARS - PHASE I

A. Conditions of Shelf-Life Test

Shelf-life tests at 30°F, 70°F, and 100°F were run on bars made from 16 of the foods listed in Section 4 of the contract specifications for Phase I. At the end of the three-month period an informal taste test indicated that the greater portion of the food bars were still satisfactory and the tests were extended for an additional month. The results of organoleptic tests conducted by a trained sensory panel at the end of the four-month period and based on the hedonic scale described in Table IX are summarized in Table X. The hedonic scale used for rating the bars range from one (dislike extremely) to nine (like extremely).

B. Results of Shelf-Life Test

1. Bars Made with Food Components

The samples of pie crust food bars held at 30°F were rated as barely acceptable, those held at 70°F were rated as borderline, and those held at 100°F as unacceptable due to the presence of incipient rancidity. The comments for the 30°F and 70°F samples ranged from acceptable to slightly dislike, since the product itself has a predominantly fatty or lard-type taste which was not considered appetizing or attractive by members of the panel.

Acceptable ratings were obtained for the cookie, graham cracker, date, orange, and chocolate food bars. Bacon bars were considered acceptable as well as scrambled egg bars, although the samples of the latter that were held at 100°F had a slightly bitter or overprocessed egg taste.

The chicken food bar was rated between almost borderline and like slightly because of the dry nature of the dehydrated chicken used and a slight denaturization of the protein at 100°F. Acceptability is increased by rehydration of the bar. All samples held at the three storage temperature levels were edible after four months.

The cheese food bars held at 30°F and 70°F were considered acceptable. However, the sample held at 100°F was rated unacceptable because of degradation of an artificial color present in the commercial cheese itself, and a slightly objectionable caramelized taste.

2. Bars Made with Soup Components

Samples of rehydrated green pea soup, beef noodle soup, and chicken noodle soup were found acceptable after being held at any of the three temperature levels for the four-month period. However, the green pea soup bar held at 100°F was given a borderline rating.

3. Bars Made with Beverage Components

Food bars made from nonfat, dried skim milk were all given unacceptable organoleptic ratings. Since the bars could not be rehydrated properly, they could not be tested as average, only out of hand. Therefore, the unacceptable ratings of this type of food bar were due partly to the taste of the chemical disintegrating agent added, in this case sodium bicarbonate and fumaric acid. The disintegrating agent was eliminated from the formulations.

The cocoa food bars were all considered as borderline cases in acceptability. Again, this was due to the addition of the bicarbonate-fumaric acid combination. The unacceptable rating was also influenced by the fact that cocoa alone is not very palatable, particularly when eaten out of hand.

The coffee food bar was rated as acceptable upon rehydration, but had too strong a flavor when eaten out of hand.

C. Conclusions of Shelf-Life Tests

In general, the food bars held at 100°F were rated below those held at the 30°F and 70°F levels. However, the overall results of the test indicate the organoleptic acceptability and storage stability of Matrix No. 18. In all cases where unacceptable organoleptic scores were obtained, it was due to failure of the food component itself, not the matrix.

XI. SHELF-LIFE TESTS ON FOOD BARS - PHASE II

A. Food, Soup, and Beverage Components

In accordance with contract specifications, food bars of 20 different food, soup, and beverage components were processed into food bars at Evans Research and Development Corporation to be used in the 6-month and 3-month shelf-life tests of Phase II of the program. The components made into bars were as follows: beef stew, chili con carne, chicken and rice, shrimp creole, tapioca pudding, chocolate pudding, plum pudding, banana cream pudding, creamed ground beef (S.O.S. type), Welsh rarebit, chicken à la king, cream of mushroom soup, beef barley soup, vegetable soup, chicken noodle soup, New England style clam chowder, coffee with cream and sugar, orange juice, tomato juice, and apricot nectar.

The majority of these components had to be freeze-dried, granulated, and incorporated with Matrix No. 18 (99 percent lactose, 1 percent carboxymethylcellulose) at Evans Research. Of the 20 components, only the chicken and rice were readily available commercially in freeze-dried form. The beef stew, chili con carne, shrimp creole, chocolate pudding, plum pudding, banana cream pudding, chicken à la king, clam chowder, tomato juice, and apricot nectar had to be freeze-dried and subsequently granulated at Evans Research.

In addition to freeze-drying and granulation, suitable formulations had to be devised at Evans Research for the tapioca pudding, creamed beef, Welsh rarebit, coffee, and orange juice.

In Table XXIII are presented the components, the forms in which they were acquired, and the processing steps carried out at Evans Research. The formulations of the food bars are given in Table XXIV.

B. Processing Procedure for the Food Bars

The following basic procedure was used in the production of the food bars:

1. Based upon the solids content of the food component, e.g. approximately 7 percent for tomato juice or 20 percent for chicken à la king, an amount adequate to yield at least 10 pounds of dry food was purchased.

2. The food was pre-frozen and subsequently freeze-dried.

The material to be freeze-dried was placed in stainless steel trays specifically designed for use in the RePP Industries freeze-drier Model No. 15. The trays were filled to a depth of 1/2 inch, and the temperature thermistor probes were then inserted into the product being freeze-dried. The "shelf temperature" thermostatic control was set at -50°F and when the material was adequately frozen, the switch labeled "Condenser Refrigeration" was turned on. When the condenser temperature read -40°F or lower, a vacuum of .005 mm Hg was attained. For perfect preservation of material it was necessary to cool the sample below its eutectic temperature and to dry the material below this temperature. When the pressure in the vacuum drum had dropped below 150 microns by the McLeod gauge, it was necessary to check the condenser temperature to make certain it read -40°F or lower. Heat was then applied; a setting of 75°F was used which was found to be compatible with the heat sensitivity of the samples. The final temperature of the freeze-dried product would be 75°F. A shelf temperature of 150°F could be used and would yield efficient drying rates, but the rehydration properties would be impaired. The 75°F temperature prolonged the drying time but yielded superior rehydration qualities in the final dried product. When shelf temperature and product temperature were the same, a residual moisture of approximately 1 percent had been obtained. The vacuum release was turned slowly and air was admitted into the vacuum drum. The samples were removed from the trays and stored in sealed containers with I.P.D.* to avoid moisture pickup.

3. The freeze-dried component was then granulated or reduced to a uniform size, i.e. a particle size which would pass through a U.S. sieve No. 20 but be retained by a U.S. sieve No. 40. The majority of the particles were retained by the No. 40 sieve; the smaller ones were discarded.

4. The necessary amount of tray-dried matrix No. 18 was added and blended thoroughly with the component using a Hobart-type mixer at low speed. A predetermined amount of glycerine was added to activate the matrix. The amounts used are indicated in Table XXIV.

5. Two ounces of the component/matrix mixture was loaded in a 2-1/2 inch die. The die was placed in a Carver Press and compressed until a pressure of 6000 pounds per square inch was registered. The time of compression was 10 seconds at 6000 psi. The pressure was released, and the food bar was removed from the die.

The above process was repeated until the required number of food bars had been produced. In cases where a

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*In-package desiccation.

dry product could be obtained directly (see Table XXIII), only granulation, step 4, and step 5 were performed.

A total of 800 two-ounce bars were produced measuring 2-1/2 inches in diameter and 1/2 inch in thickness. While the laboratory method of production is tedious and time-consuming, primarily because it is necessary to reset the die manually for each operation, a large-scale plant procedure to produce large volumes quickly and inexpensively can be devised readily.

The 800 bars produced were used in shelf-life and specification tests. For the 6-month shelf-life test, a minimum of three bars of each component/matrix mixture was placed in a pouch consisting of laminated layers of Kraft paper, polyethylene, aluminum foil, and polyethylene. The pouches were stored at the contract-specified temperatures of 100°F, 70°F, and 30°F.

The 3-month shelf-life tests were conducted at temperatures of 100°F, 70°F, and 0°F. In addition, the samples stored at 0°F were cycled for 24-hour intervals between 0°F and 70°F. A minimum of three food bars per container was packed.

A successful vacuum could not be drawn and maintained on the pouch as specified in the contract. A preformed pouch with a vacuum filler was necessary, but since a vacuum fill does not lend itself efficiently to the type of packaging material initially specified, a metal container* was utilized for the bars in the 3-month shelf-life tests. The advantage of this procedure is that a definite controlled vacuum can be obtained and maintained. Consequentially, more accurate determinations concerning any flavor loss and stability of bars packed under a vacuum could be obtained.

C. Results of Phase II 6-Month and 3-Month Storage Tests

1. Three-Month Tests

All samples were found to be organoleptically acceptable in the three-month storage test. The only objectionable feature found was the "fusing" of the orange bars

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*Supplied by American Can Company.

when packed together in tin cans. The flavor was acceptable. The answer to the problem is to reverse the amount of crystals from its high level 80% to 20% while increasing the matrix. The results of the Hedonic tests are listed in Table XXIX.

2. Six-Month Tests

With the exception of the 100°F Shrimp Creole and the Welsh Rarebit, all samples performed well in the six-month tests. The shrimp creole had a noticeable "amine" aroma and taste while the "rarebit" had an off-color, probably due to the artificial color used in the spray-dried fa.

It was noticeable, however, that some of the bars became very tough on storage; the items most affected in this manner were the dry puddings, i.e. tapioca. The nature of the product tends toward this type of hardening. On the over-all picture, however, all the samples performed well. The results of the tests are listed in Table XXX, and a comparison of ratings of six and three months storage samples are given in Table XXXI.

3. Conclusions of Shelf-Life Tests

All the samples after six months met the required specifications. Most important all samples dissolved in hot water with agitation under 15 minutes. Solubility readings for Phase II food bars are listed in Table XXXII. Under the conditions at the Evans Research Laboratories, all food bars were acceptable, with the exception of the orange and tapioca puddings. Even the above deviations can be reformulated to insure acceptance in future tests. The summary of the penetration tests are listed in Table XXXIII, while the list of product density is found in Table XXXIV.

TABLE I

LISTING OF INGREDIENTS TESTED FOR

COMPOSITIONS C AND D

Proteins

Supplier	Ingredient
Archer-Daniels-Midland Company	D-303 Protein D-303 Proteinate
Carnation Company	Nonfat Dry Milk Solids
Central Soya	Promine-D (clarified) Promosoy - 100
General Mills, Inc.	Toasted Soy Protein TSP 25 Toasted Full Fat Soy Flour (BL 7020) Toasted Soy Protein No. 100R Pro 80, Vital Wheat Gluten LSP 15 (Soy Flour)
Gunther Products	NV Protein D-100
Land-O-Lakes Creameries, Inc.	Edible Sodium Caseinate
Ralston Purina Company	Spun Soy Protein
Sheffield Chemical	Calcium Caseinate Potassium Caseinate Ammonium Caseinate Sodium Caseinate High Nitrogen Casein Sheftene 60 Lactalbumin
J. O. Whitten Company, Inc.	Gelatin XXX

Carbohydrates

Supplier	Ingredient
American Sugar Refining Company	Sucrose Sugar, light brown Sugar, dark brown Confectionery Sugar

TABLE I

(Continued)

Carbohydrates
(Continued)

Supplier	Ingredient
Corn Products Company	Corn Syrup
Foremost Dairies, Inc.	Lactose
General Mills, Inc.	All-Purpose Flour
Gerber Products Company	Barley Cereal Rice Cereal Oatmeal Cereal
Idaho Potato Growers, Inc.	Diced Potatoes Crushed Potatoes Powdered Potatoes Treated Diced Potatoes Riced Potatoes
National Oats Company	Oat Flour, Lab 109 Oat Flour, Lab 16 Rolled Oats Quick Oats Oat Chips Crushed Oat Flakes Oat Crumbles Oat Bits Baby Oat Flakes Steelcut Oat Groats
National Starch Products	Clearjel Starch, Instant
John Paton, Inc.	Honey
Penick & Ford, Ltd., Inc.	Molasses
J. R. Simplot Company	Idaho Mashed Potatoes (g Potato Crystals Potato Dices 1/4" x 1/4" Potato Dices 3/8" x 3/8"
Stein Hall & Company, Inc.	Potato Starch
Several Sources	Rice Flour

TABLE I

(Continued)

Fats

Supplier	Ingredient
Beatrice Foods Company	Beatreme C Beatreme 1535 Beatreme Creeme
Procter and Gamble Company	Hydrogenated Fat
Local Purchase	Butter Margarine Lard

Gums, etc.

Supplier	Ingredient
DuPont	Elvanol PVA (50-42)
General Mills, Inc.	Supercal GF
Kelco Company	Kelco Gel LV Kelcoloid HV
Marine Colloids	Sodium Alginate SX-3 Carrageenan MAC
Morningstar Paisley, Inc.	Gum Ghatti, powder #1
National Dairy Products Corp.	Kraystay Type K
Stein Hall & Company, Inc.	Gum Guar #1 HV

TABLE II

PROTOTYPE FORMULATIONS

Formula 7	4.00%	Hydrogenated vegetable shorte
	1.20%	Promine-D (Clarified)
	4.00%	Sugar granulated
	0.20%	Gelatin XXX
	0.40%	Clearjel starch
	0.20%	Elvanol 50-42 (PVA)
	10.00%	Water
	80.00%	Green Pea Soup, dehydrated*
Formula 14	4.00%	Hydrogenated vegetable shorte
	0.40%	Promine-D (Clarified)
	2.00%	Sugar granulated
	2.00%	Sugar 10X
	0.40%	Clearjel Starch
	0.40%	Elvanol 50-42 (PVA)
	10.00%	Water
	80.80%	Food material*
Formula 15	99.00%	Sugar granulated
	1.00%	Elvanol 50-42 (PVA)
Formula 16	99.00%	Invert
	1.00%	Elvanol 50-42 (PVA)

*Added component

TABLE III

COMPOSITION OF MATRIX PROTOTYPES

Matrix	Formula	Kg-Cal per gram	Protein (%)	Carbohydrate (%)	Fat (%)	Ash (%)
Composition C	Formula 7	6.1	14.08	44.90	40.81	0.21
	Formula 14	6.3	4.24	49.83	45.82	0.11
Composition D	Formula 15	3.8	0.0	99.0	0.0	trace
	Formula 16	3.8	0.0	99.0	0.0	trace

TABLE IV

GENERAL PURPOSE MATRIX FORMULATIONS

Formula 17	99.00%	Dextrose
	1.00%	Carboxymethylcellulose
Formula 18	99.00%	Lactose
	1.00%	Carboxymethylcellulose
Formula 19	99.00%	Maltose
	1.00%	Carboxymethylcellulose
Formula 20	99.00%	Cornstarch
	1.00%	Carboxymethylcellulose
Formula 21	99.00%	Soluble starch
	1.00%	Carboxymethylcellulose
Formula 22	99.00%	Lactose
	1.00%	Methylcellulose
Formula 23	99.00%	Lactose
	1.00%	Methylcellulose-hydroxypropylmethylcellulose mixtur
Formula 24	99.00%	Lactose
	1.00%	Hydroxyethylcellulose
Formula 25	99.00%	Lactose
	1.00%	1 to 1 mixture of polyvinylalcohol and hydroxyethylcellulose
Formula 26	97.50%	Lactose
	2.50%	1 to 1 mixture of polyvinylalcohol and hydroxyethylcellulose
Formula 27	95.00%	Lactose
	5.00%	1 to 1 mixture of polyvinylalcohol and hydroxyethylcellulose
Formula 28	55.40%	Lactose
	0.60%	Polyvinylalcohol
	24.00%	Glycerine
	16.00%	Sodium bicarbonate
	4.00%	Fumaric acid
Formula 29	99.00%	Lactose
	1.00%	Cellulose acetate phthalate

TABLE V

METHOD OF FOOD BAR PREPARATION

I. General Matrix

The general matrix was produced in the following manner:

A. Ninety-nine parts of sugar were dissolved in water.

B. One part of polymer was dispersed in water.

C. Solutions 1 and 2 were blended and diluted to 1000 parts with water.

D. The blended mixture was then freeze dried and ground into a free flowing powder.

II. Food Bar

The food bar was manufactured by the following procedure:

A. A predetermined quantity (80%) of the food component was weighed out together with a maximum of 20% matrix, and the mixture was dry blended.

B. In most cases a small quantity of water is added to the dry blend to activate the matrix. The amount of water incorporated into the food bar does not have to be baked out or removed. Some of the water may be replaced by glycerol to aid in rehydration.

C. In food bars for beverages with chemical leavening agents, glycerol is used in place of water in order to prevent premature reaction of the reagents and to permit rapid dispersion in water.

D. A predetermined amount of the food component-matrix blend is weighed out.

E. The weighed material is then either hand molded or placed in a pressure molding apparatus and shaped to the desired density and physical properties.

Formula No.*	Flavored Ingredient		Amount of Bland Ingredients in Bar (g)					
	Type	Amount (g)	Matrix Formula 18**	$NaHCO_3$	Fumaric Acid	Glycerin	Mono or Di-glycerides	Water
S-1	Pea Soup	250	35	20	5	15	-	-
S-2	Beef Noodle Soup	250	35	20	5	15	-	-
S-3	Chicken Noodle Soup	250	35	20	5	15	-	-
S-4	Cream of Mushroom Soup	250	35	20	5	20	-	-
F-1	Cheese	250	35	-	-	30	-	-
F-2	Freeze Dried Chicken	250	35	-	-	60	-	-
F-3	Graham Crackers	250	35	-	-	10	-	-
F-4	Date Powder	240	50	-	-	10	-	-
F-5	Scrambled Eggs	250	50	-	-	-	-	5
F-6	Sweet Chocolate	240	35	-	-	-	-	-
F-7	Lorna Doone Cookies	250	50	-	-	-	.	-
F-8	Pie Crust	240	60	-	-	-	-	-
F-9	Bacon	250	60	-	-	-	-	-
F-10	Peanuts	240	50	-	-	-	-	25
B-1	Milk	250	25	20	5	10	5	-
B-2	Orange Crystals	250	35	20	5	10	-	-
B-3	Cocoa	240	28	16	4	20	-	-
B-4	Coffee	265	20	40	10	25	-	-

*S = soup, F = food and B = beverage
**1% lactose, 99% carboxymethylcellulose

TABLE VII

PACKAGING OF FOOD BARS

FOR STORAGE STABILITY TESTING

Types of Soup, Food and Beverage Bars Produced	18
Number of Pouches Produced for Each Type of Bar	6
Total Number of Pouches* Produced	108
Number of Bars in Each Pouch	5
Total Number of Bars Produced	540

*Packed in air

TABLE VIII

CONDITIONS UNDER WHICH BARS ARE STORED FOR STABILITY TESTING

Temperature (°F)	Packaging				
	Flavors	No.of Pouches For Each Flavor	Total Number of Pouches	No.of Bars in Each Pouch	Tot of l
30	18	2	36	5	18
70	18	2	36	5	18
100	18	2	36	5	18
Grand Total					54

TABLE IX

HEDONIC SCALE

9 Like extremely

8 Like very much

7 Like moderately

6 Like slightly

5 Neither like nor dislike

4 Dislike slightly

3 Dislike moderately

2 Dislike very much

1 Dislike extremely

TABLE X

HEDONIC SCALE RATINGS OF PHASE I FOOD BARS

AFTER FOUR MONTHS STORAGE

Flavor	Temp. °F	Individual Ratings						Total	Average
Pie Crust	30	4	7	5	6	6	6	34	5.66
	70	4	7	4	5	4	6	30	5.00
	100	3	7	3	3	4	3	23	3.83
Cookies	30	7	8	9	7	5	6	42	7.00
	70	7	8	7	7	5	7	43	7.16
	100	6	9	8	5	5	5	38	6.33
Graham Cracker	30	9	8	9	6	8	8	48	8.00
	70	7	8	9	6	7	7	44	7.33
	100	5	8	9	6	6	7	41	6.83
Dates	30	8	8	8	8	7	4	43	7.16
	70	8	8	8	8	7	5	44	7.33
	100	8	8	8	8	7	6	45	7.50
Orange	30	8	7	7	8	4	4	38	6.33
	70	7	7	7	8	6	4	39	6.50
	100	5	7	7	6	6	3	34	5.66
Chocolate	30	9	9	9	9	9	8	53	8.83
	70	8	9	9	9	9	8	52	8.66
	100	7	9	9	4	9	7	45	7.50
Bacon	30	9	9	8	6	7	7	45	7.50
	70	8	9	8	6	6	7	44	7.33
	100	6	9	8	6	5	8	42	7.00
Cheese	30	7	9	8	3	7	6	40	6.66
	70	5	8	7	3	6	6	35	5.83
	100	2	8	5	2	5	6	28	4.66
Chicken	30	4	8	8	3	6	5	34	5.66
	70	5	8	8	3	5	7	36	6.00
	100	3	8	7	3	5	7	33	5.50
Scrambled Eggs	30	8	9	6	6	7	9	45	7.50
	70	7	8	5	6	7	7	40	6.66
	100	6	8	5	5	5	6	35	5.83
Green Pea Soup (rehydrated)	30	7	7	9	4	6	6	39	6.50
	70	6	7	9	3	5	6	36	6.00
	100	1	7	8	3	5	6	30	5.00
Beef Noodle Soup (rehydrated)	30	8	8	9	3	9	8	45	7.50
	70	7	8	9	4	8	7	43	7.16
	100	3	7	8	4	8	6	36	6.00
Chicken Noodle Soup (rehydrated)	30	8	8	9	7	8	8	48	8.00
	70	6	8	9	7	7	7	44	7.33
	100	5	6	7	6	5	7	36	6.00
Milk	30	6	6	2	3	3	2	22	3.66
	70	6	7	2	3	3	4	25	4.16
	100	6	6	1	3	3	3	22	3.66
Coffee (rehydrated)	30	6	6	8	6	5	6	37	6.16
	70	4	6	8	4	5	5	32	5.33
	100	2	5	8	4	5	6	30	5.00
Cocoa	30	2	9	7	3	5	6	32	5.33
	70	2	9	7	3	5	6	32	5.33
	100	1	9	7	3	5	6	31	5.16

TABLE XI

FORMULAS FOR GRAHAM CRACKER BARS

USED IN PRELIMINARY COMPARISON

Matrix No. 18

Ingredient		Amount of Ingredients in Bar (g)			
		No. 1	No. 2	No. 3	No. 4
Graham Crackers (ground)*		200	200	200	200
Binder**	Freeze-Dried	-	-	28	-
	Spray-Dried	-	-	-	28
	Tray-Dried (#2)	28	-	-	-
	Dry-Mixed	-	28	-	-
Glycerine		8	8	8	8

*Passed through No. 10 sieve

**Passed through No. 60 sieve

TABLE XII

FORMULAS FOR CREAM OF MUSHROOM BARS

USED IN PRELIMINARY COMPARISON

Matrix No. 18

Ingredient		Amount of Ingredients in Bar (g)			
		No. 1	No. 2	No. 3	No. 4
Cream of Mushroom Soup*		200	200	200	200
Binder**	Freeze-Dried	-	28	-	-
	Spray-Dried	-	-	28	-
	Tray-Dried	28	-	-	-
	Dry-Mixed	-	-	-	28
Glycerine		16	16	16	16
Sodium Bicarbonate		16	16	16	16
Fumaric Acid		4	4	4	4

*Passed through No. 10 sieve.

**Passed through No. 60 sieve.

TABLE XIII

CONDITIONS FOR SPRAY-DRYING MATRIX NO. 18

Conditions		Run No.					
		1	2	3	4	5	6
Feed	Feed Make-up	Sample as received	Sample as received	Sample as received	Increased solids concentration by using powder from run No. 3	Increased solids concentration by using powder from run No. 3	Lactose sample as received
	Solids (wt. %)	6	6	6	18	30	15
	Specific gravity	1.033	1.033	1.033	1.068	1.099	1.062
	Description	Solution	Solution	Solution	Solution	Solution	Solution
	Temperature	Room	Room	Room	Room	Room	Room
	Feed rate (ml/min)	50	70	120	100	90	110
	Amount fed (ml)	500	1,500	12,000	1,000	500	16,000
Operating	Inlet air temperature (°F)	450	650	700	500	500	650
	Outlet air temperature (°F)	140	190	200	175	185	170
	Upper cold air ports	Closed	Closed	Closed	Closed	Closed	One Open
	Lower cold air ports	Closed	Closed	Closed	Closed	Closed	Closed
	Atomizing speed (RPM)	48,000	48,000	48,000	48,000	48,000	[illegible]
	Weather conditions	Clear and dry	Clear and dry	Clear and dry	Clear and dry	Clear and dry	Snowy, some humid.
	Chamber condition	Upper section coated with sticky powder	Lightly coated	Lightly coated	Ring opposite atomizer	Light ring opposite atomizer	Lightly coated
Product	Collector product (g)	N.R.	86	698	176	150	2300
	Chamber product (g)	Washed	Brushed	Brushed	Brushed	Brushed	100
	Total product (g)	N.R.	86	698	176	150	2400
	Bulk density (loose-packed, g/cc)	-	Heavy	Heavy	Heavy	Heavy	Heavy
	Color characteristics	White	White	White	White	White	White
	Moisture (%)	-	-	-	-	-	1.2
	Recovery (%)	-	92.5	94.4	91.8	91.5	94.3
Comments		The lactose solution spray-dried very satisfactorily when the solids were raised to either 18 or 30 %, with the best results obtained at the higher figure. At the original low solids content, it was necessary to dry so much water that the powder would become tacky before collecting.					

TABLE XIV

CONDITIONS FOR FORCED-AIR TRAY DRYING

Matrix No. 18

Conditions		Run 1	Run 2	Run 3*	Run 4**
Ingredients of Mixture (g)	Lactose	168.3	495.0	168.3	168.3
	CMC - 7LP	1.7	5.0	1.7	1.7
	Water	828.3	500.0	65.0	30.0
Temperature (°F)		190.0	190.0	190.0	190.0
Time (hrs)		5	5	3	3

* A granulation was made by dissolving the CMC in water and slowly adding the lactose.

** A paste was prepared by dissolving the CMC in the water and blending in the lactose. The paste was spread out on a tray to dry.

TABLE XV

FORMULAS FOR BARS USED TO DETERMINE

OPTIMUM CONDITIONS FOR TRAY DRYING

Matrix No. 18

Ingredient		Amount of Ingredient Added to Bar (g)							
		1	2	3	4	5	6	7	8
Cream of Mushroom Soup (ground)		200	200	200	200	200	200		
Graham Crackers (ground)								200	200
Binder No.	1	28						28	
	2		28	28					28
	3				28				
	4					28			
	5						28		
Glycerine		12	12	20	12	12	12	8	8
$NaHCO_3$		16	16	16	16	16	16		
Fumaric Acid (food grade)		4	4	4	4	4	4		

TABLE XVI

FORMULAS FOR BARS MADE FROM GRAHAM CRACKERS

AND THE UNPROCESSED COMPONENTS OF MATRIX

Matrix No. 18

Ingredient	Amount of Ingredient in Bar (g)		
	No. 1	No. 2	No. 3
Graham Crackers (ground) *	200	200	200
Glycerine	8	8	8
Lactose	-	28	-
CMC - 7LP	-	-	0.3

* Passed through No. 10 sieve

TABLE XVII

FORMULAS FOR BARS MADE FROM CREAM OF MUSHROOM SOUP

AND THE UNPROCESSED COMPONENTS OF MATRIX

Matrix No. 18

Ingredient	Amount of Ingredient in Bar (g)		
	No. 1	No. 2	No. 3
Cream of Mushroom Soup (ground)	200	200	200
Sodium Bicarbonate	16	16	16
Fumaric Acid (food grade)	4	4	4
Lactose	-	28	-
CMC - 7LP	-	-	0.26

TABLE XVIII

PENETRATION READINGS ON GRAHAM CRACKER BARS USED IN PRELIMINARY COMPARISON

Matrix No. 18

Sample Description	Sample No.	Individual Penetration Readings										Average
Freeze-Dried Binder	1	130	135	180	175	175	170	145	170	165	165	161.0
Spray-Dried Binder	2	280	230	215	240	240	210	180	220	260	330	240.5
Air-Dried Binder	3	105	110	105	110	105	115	105	120	110	105	109.0
Dry-Mixed Binder	4	110	115	125	115	105	120	115	110	115	115	114.5
Graham Crackers Alone	5	230	230	235	235	250	240	220	220	230	245	233.5
Lactose (Spray-Dried)	6	200	220	230	210	210	200	190	210	220	205	209.5
CMC - 7LP	7	215	200	210	205	210	210	220	220	210	215	211.5

TABLE XIX

FORMULAS OF PHASE II FOOD BARS

USED IN COMPARISON OF MATRIX NO. 18

Ingredient	Amount of Ingredient Added to Bar (g)											
	1	2	3	4	5	6	7	8	9	10	11	12
Orange Juice (freeze-dried)	50	50	50	-	-	-	-	-	-	-	-	-
Cream of Mushroom Soup (powdered)	-	-	-	50	50	50	-	-	-	-	-	-
Chicken Noodle Soup (powdered)	-	-	-	-	-	-	50	50	50	-	-	-
Chocolate Pudding (freeze-dried)	-	-	-	-	-	-	-	-	-	50	50	50
Binder: Freeze-Dried	7	-	-	7	-	-	7	-	-	7	-	-
Binder: Spray-Dried	-	7	-	-	7	-	-	7	-	-	7	-
Binder: Tray-Dried	-	-	7	-	-	7	-	-	7	-	-	7
Glycerine	2	2	2	2	2	2	2	2	2	2	2	2

TABLE XX

PENETRATION READINGS

ON PHASE II FOOD BARS

Food Compo- nent	Binder	Sample No.	Individual Penetration Readings										Average
Orange Juice	Freeze-Dried	1	150	150	145	115	130	140	105	110	110	130	128.5
	Spray-Dried	2	125	115	115	115	120	120	120	120	125	130	120.5
	Tray-Dried	3	90	90	110	90	100	105	115	120	115	110	103.5
Cream of Mushroom Soup	Freeze-Dried	4	205	195	180	180	205	185	190	200	200	210	195.0
	Spray-Dried	5	185	185	190	190	190	180	205	185	185	185	188.0
	Tray-Dried	6	165	165	175	165	170	160	170	175	165	165	167.5
Chicken Noodle Soup	Freeze-Dried	7	175	180	180	170	190	215	180	200	200	170	186.0
	Spray-Dried	8	200	180	180	190	185	185	210	215	200	210	197.5
	Tray-Dried	9	195	200	230	230	200	200	210	225	225	200	213.5
Choco- late Pudding	Freeze-Dried	10	90	100	110	95	90	110	95	110	95	105	100.0
	Spray-Dried	11	90	90	100	105	95	110	90	90	85	85	94.0
	Tray-Dried	12	80	80	90	85	90	75	90	80	80	80	83.0

TABLE XXI

HEDONIC RATINGS GIVEN PHASE II FOOD BARS

Food Component	Matrix	Sample No.	Individual Ratings						Average
Orange Juice	Freeze-Dried	1	8	7	4	6	6	2	5.50
	Spray-Dried	2	8	5	4	7	7	9	6.66
	Tray-Dried	3	8	7	4	7	7	8	6.83
Cream of Mushroom Soup	Freeze-Dried	4	7	5	8	5	5	6	6.00
	Spray-Dried	5	8	5	6	5	5	9	6.33
	Tray-Dried	6	8	5	7	5	5	8	6.33
Chicken Noodle Soup	Freeze-Dried	7	7	7	6	5	3	7	5.83
	Spray-Dried	8	7	7	7	6	3	8	6.33
	Tray-Dried	9	7	6	5	5	3	7	5.50
Chocolate Pudding	Freeze-Dried	10	9	8	8	9	7	7	8.00
	Spray-Dried	11	9	9	8	7	7	9	8.16
	Tray-Dried	12	9	7	7	8	7	8	7.66

TABLE XXII

TIME OF SOLUTION

OF PHASE II FOOD BARS

Sample No.	Food Component	Binder	Time of Solution (min)
1	Orange Juice	Freeze-Dried	30
2		Spray-Dried	24
3		Tray-Dried	29
4	Cream of Mushroom Soup	Freeze-Dried	50
5		Spray-Dried	42
6		Tray-Dried	36
7	Chicken Noodle Soup	Freeze-Dried	55
8		Spray-Dried	37
9		Tray-Dried	30
10	Chocolate Pudding	Freeze-Dried	77
11		Spray-Dried	83
12		Tray-Dried	80

TABLE XXIII

SOURCE OF FOOD COMPONENTS FOR PHASE II

FOOD BARS

	Food Component	Form Used	Processing at Evans Research
	Beef Stew	Canned	Freeze-dried granulated
asserole Items	Chili Con Carne	Canned	Freeze-dried granulated
	Chicken and Rice	Freeze-dried	Granulated
	Shrimp Creole	Frozen	Freeze-dried granulated
	Tapioca	Formulated at Evans	Freeze-dried granulated
ıddings	Chocolate	Dry Powder	Reconstituted, freeze-dried and granulated
	Plum	Canned	Freeze-dried granulated
	Banana Cream	Dry Powder	Reconstituted, freeze-dried and granulated
	Creamed Beef (S.O.S.)	Formulated at Evans in dry form	Granulated
reamed Items	Chicken à la King	Canned	Freeze-dried granulated
	Cream of Mushroom Soup	Dry Powder	Granulated
	Welsh Rarebit	Formulated at Evans	Freeze-dried granulated
	Beef with Barley Soup	Dry Powder	Granulated
oups	Clam Chowder*	Canned	Freeze-dried granulated
	Vegetable Noodle Soup	Dry Powder	Granulated
	Chicken Noodle Soup	Dry Powder	Granulated
	Coffee with Cream + Sugar	Formulated at Evans	Freeze-dried granulated
verages	Orange Juice	Formulated at Evans	Granulated
	Tomato Juice	Canned, liquid	Freeze-dried granulated
	Apricot Nectar	Canned, liquid	Freeze-dried granulated

*New England Style

TABLE XXIV

FORMULAS OF PHASE II FOOD BARS

Beef Stew freeze-dried	1000 gm
Binder tray-dried	140 gm
Glycerine	80 gm
Chili con Carne freeze-dried	1000 gm
Binder tray-dried	140 gm
Clearjel Starch - Instant	64 gm
Water	40 gm
Glycerine	80 gm
Chicken and Rice	
Rice and Chicken Dinner freeze-dried by Armour	1000 gm
Binder tray-dried	140 gm
Glycerine	70 gm
Shrimp Creole freeze-dried	1000 gm
Binder tray-dried	140 gm
Glycerine	60 gm
Tapioca Pudding freeze-dried	1000 gm
Binder tray-dried	140 gm
Glycerine	90 gm
Chocolate Pudding freeze-dried	1000 gm
Binder tray-dried	140 gm
Glycerine	120 gm
Plum Pudding freeze-dried	1000 gm
Binder tray-dried	140 gm
Glycerine	40 gm
Banana Cream Pudding (Jell-O)	1000 gm
Binder tray-dried	140 gm
Glycerine	70 gm

TABLE XXIV

(Continued)

Creamed Beef (SOS type)	
Beef freeze-dried	500 gm
Instant Jel Starch	172 gm
Non-Fat Dry Milk Solids-Instant	260 gm
Instant Clearjel Starch	58 gm
Pepper (Saromex "S")	2 gm
Onion (Saromex "S")	2 gm
Salt	4 gm
Binder tray-dried	140 gm
Glycerine	160 gm
Chicken à la King freeze-dried	1000 gm
Binder tray-dried	140 gm
Glycerine	80 gm
Cream of Mushroom Soup (Red Kettle)	1000 gm
Binder tray-dried	140 gm
Glycerine	120 gm
Welsh Rarebit	
Clearjel-Instant	150 gm
Non-Fat Dry Milk Solids-Instant	400 gm
Beatreme Cheddar 1736 A	180 gm
Beatreme Cheddar 1326	180 gm
Beatreme Parmesan 1322	80 gm
Salt	4 gm
Pepper (Saromex "S")	2 gm
Dry Mustard	6 gm
Binder tray-dried	140 gm
Glycerine	160 gm
Beef Barley Soup (Red Kettle)	1000 gm
Binder tray-dried	140 gm
Glycerine	80 gm
Clam Chowder freeze-dried	1000 gm
Binder tray-dried	140 gm
Glycerine	80 gm
Vegetable Noodle Soup (Red Kettle)	1000 gm
Binder tray-dried	140 gm
Glycerine	80 gm

TABLE XXIV

(Continued)

Chicken Noodle Soup (Red Kettle)	1000 gm
Binder tray-dried	140 gm
Glycerine	100 gm
Coffee with Cream and Sugar	
Instant Coffee (Sanka)	260 gm
Powdered Cream (Coffee-Mate)	480 gm
Sodium Cyclamate	7.4 gm
Sodium Saccharin	.6 gm
Binder tray-dried	140 gm
Glycerine	80 gm
Sugar	240 gm
Orange Juice	
Orange Crystals (McKee's)	1000 gm
Starch (Col Flo 67)	100 gm
Binder tray-dried	140 gm
Glycerine	80 gm
Tomato Juice freeze-dried	1000 gm
Starch (Col Flo 67)	100 gm
Binder tray-dried	140 gm
Glycerine	60 gm
Apricot Nectar freeze-dried	1000 gm
Instant Clearjel Starch	50 gm
Binder tray-dried	140 gm
Glycerine	90 gm

TABLE XXV

PENETRATION AND SOLUBILITY TESTS ON 2-1/2 INCH FOOD BARS MADE WITH MATRIX NO. 18, SPRAY-DRIED BY EVANS RESEARCH AND BY FOREMOST DAIRIES, INC.

Food Component	Matrix	Penetration Value in Millimeters	Solubility Value in Minutes	Six - Foot Drop Test
hicken à la King	SDE* SDFD**	Breaks in Test 109	50 26	Failed Cracked
hili con Carne	SDE SDFD	337 175	40 24	Cracked Chipped
ream of Mushroom Soup	SDE SDFD	188 82	42 22	Cracked Passed
hocolate Pudding	SDE SDFD	94 47	83 47	Cracked Passed
ange Juice	SDE SDFD	120 49	52 28	Cracked Passed
ef Barley Soup	SDE SDFD	205 81	57 45	Cracked Passed

*Spray-dried by Evans Research

**Spray-dried by Foremost Dairies, Inc.

TABLE XXVI

PENETRATION TESTS ON FOOD BARS CONTAINING

PLASTIC-TYPE FAT*

Food Bars	Penetration Value (mm)	
	Without Fat	With Fat
Chicken à la King	287	410
Cream of Mushroom Soup	167	202
Plum Pudding	111	187
Chicken Soup	213	183
Beef Stew	185	234

*Ratio of fat to matrix 1:1

TABLE XXVII

CALORIE VALUE OF FOOD BARS

Food Bar	Calories/Ounce
Clam Chowder	110.57
Tapioca Pudding	164.43
Cream of Mushroom	147.42
Beef Barley	110.57
Chicken Noodle	121.91
Vegetable Noodle	113.40
Chicken à la King	170.10
Plum Pudding	141.75
Shrimp Creole	119.07
Chocolate Pudding	116.24
Chili con Carne	136.08
Coffee with Cream and Sugar	158.76
Beef Stew	124.74
Orange Juice	124.30
Welsh Rarebit	138.92
Beef (Chipped Beef on Toast Type)	124.74
Banana Cream Pudding	119.07
Tomato Juice	110.60
Apricot Nectar	122.40
Chicken and Rice	144.59

TABLE XXVIII

REVISED FORMULAS FOR TOMATO JUICE, ORANGE JUICE AND APRICOT NECTAR

The following formulas were prepared in order to raise the caloric value of the Tomato Juice, Orange Juice, and Apricot Nectar food bars so that these bars would meet government requirements:

Tomato Juice	
Tomato Juice (Revised)	142 gm
Freeze-Dried Tomato Juice	25 gm
Instant Clearjel Starch	24 gm
Tray-Dried Binder	15 gm
Beatreme "C"	15 gm
Orange Juice Revised	
Orange Juice Crystals (McKees)	154 gm
Col Flo 67 Starch	17 gm
Beatreme "C"	13 gm
Tray-Dried Binder	23 gm
Glycerine	13 gm
Apricot Nectar Revised	
Freeze-Dried Apricot Nectar	154 gm
Col Flo 67 Starch	17 gm
Beatreme "C"	13 gm
Tray-Dried Binder	23 gm
Glycerine	13 gm

TABLE XXIX

HEDONIC SCALE RATINGS OF PHASE II FOOD BARS AFTER THREE MONTHS OF STORAGE (VACUUM PACKED IN METAL CANS)

Flavor	Temp. °F	Rater No. 1	2	3	4	5	6	Total	Average
Beef Stew	100	8	5	6	8	3	7	37	6.2
	70	8	6	7	8	4	8	41	6.8
	35	9	6	7	8	5	7	42	7.0
	0-70	8	6	7	8	4	7	40	6.7
Clam Chowder	100	7	3	6	7	4	7	34	5.7
	70	8	5	7	7	5	8	39	6.5
	35	7	5	7	7	6	8	40	6.7
	0-70	7	5	7	7	5	7	38	6.3
Shrimp Creole	100	8	6	5	7	3	7	37	6.2
	70	8	7	6	7	4	8	40	6.7
	35	9	7	7	7	7	8	45	7.5
	0-70	8	7	6	7	5	7	40	6.7
Beef S.O.S.	100	9	8	5	7	4	8	41	6.8
	70	9	8	6	6	5	8	42	7.0
	35	9	8	7	6	5	8	43	7.2
	0-70	8	8	6	6	5	8	41	6.8
Apricot Nectar	100	8	7	8	7	7	9	46	7.7
	70	7	8	9	7	8	9	48	8.0
	35	7	8	9	7	8	9	48	8.0
	0-70	7	8	8	7	8	8	46	7.7
Tomato Juice	100	7	4	6	8	4	7	36	6.0
	70	7	6	7	8	7	8	43	7.2
	35	8	7	8	8	7	8	46	7.7
	0-70	7	6	7	8	7	7	42	7.0
Tapioca Pudding	100	8	8	6	8	5	7	42	7.0
	70	8	8	7	8	7	8	46	7.7
	35	7	8	8	8	7	8	46	7.7
	0-70	7	8	7	8	7	7	44	7.3
Chicken a la King	100	8	4	7	7	3	6	35	5.8
	70	9	6	8	7	4	7	41	6.8
	35	8	7	8	7	4	7	41	6.8
	0-70	8	6	7	7	5	7	40	6.7
Chicken and Rice	100	7	5	5	6	5	6	34	5.7
	70	7	6	6	7	6	7	39	6.5
	35	7	7	7	7	7	7	42	7.0
	0-70	7	6	6	7	6	7	39	6.5
Orange Juice	100	7	4	5	8	7	7	38	6.3
	70	7	8	6	7	7	8	43	7.2
	35	7	8	7	6	7	8	44	7.3
	0-70	7	8	6	7	7	7	42	7.0
Chicken Noodle Soup	100	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	38	6.3
	70	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	42	7.0
	35	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	43	7.2
	0-70	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	42	7.0
Beef Barley Soup	100	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	40	6.7
	70	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	44	7.3
	35	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	0-70	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	42	7.0
Banana Cream Pudding	100	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	42	7.0
	70	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	47	[illegible]
	35	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	0-70	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Coffee	100	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	45	[illegible]
	70	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	45	[illegible]
	35	7	[illegible]	[illegible]	[illegible]	7	[illegible]	47	[illegible]
	0-70	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	45	[illegible]
Chili	100	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	6.0
	70	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	40	[illegible]
	35	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	41	[illegible]
	0-70	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	40	[illegible]
Chocolate Pudding	100	8	7	7	[illegible]	[illegible]	[illegible]	47	7.8
	70	9	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	49	8.2
	35	9	9	[illegible]	[illegible]	[illegible]	[illegible]	51	8.5
	0-70	9	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	49	8.2
Cream of Mushroom Soup	100	7	6	8	6	6	7	38	[illegible]
	70	7	6	7	6	7	6	39	6.5
	35	7	6	7	6	7	6	39	6.5
	0-70	7	6	7	6	7	6	39	6.5
Vegetable Noodle Soup	100	8	5	6	7	6	8	38	[illegible]
	70	9	8	7	8	6	7	43	7.2
	35	9	9	7	8	7	7	45	7.5
	0-70	9	8	7	8	6	7	43	7.2
Welsh Rarebit	100	9	4	8	9	5	8	41	6.8
	70	9	6	7	9	6	8	45	7.5
	35	9	6	7	9	7	8	46	7.7
	0-70	9	6	7	9	6	8	45	7.5
Plum Pudding	100	7	8	8	8	8	9	48	8.0
	70	7	9	9	8	8	9	50	8.3
	35	8	9	9	8	8	9	51	8.5
	0-70	7	9	9	8	8	9	50	8.3

TABLE XXX

HEDONIC SCALE RATINGS OF PHASE II FOOD BARS AFTER SIX MONTHS OF STORAGE (PACKED IN POUCHES)

Flavor	Temp. °F.	Rater No. 1	2	3	4	5	6	Total	Average
Beef Stew	100	6	5	7	6	5	8	37	6.2
	70	7	6	8	8	6	8	43	7.2
	35	7	6	8	8	7	8	44	7.3
	0-70	7	6	7	8	7	8	43	7.2
Clam Chowder	100	6	4	5	7	2	7	31	5.2
	70	6	6	6	7	4	7	36	6.0
	35	7	7	7	7	5	7	40	6.7
	0-70	6	5	6	7	6	7	37	6.2
Shrimp Creole	100	4	4	3	7	2	6	26	4.3
	70	5	6	5	8	2	7	33	5.5
	35	6	6	6	8	3	7	36	6.0
	0-70	6	6	6	8	4	7	37	6.1
Beef SOS	100	6	5	5	6	5	7	34	5.7
	70	7	6	5	7	6	7	38	6.3
	35	8	6	5	8	6	7	40	6.7
	0-70	8	6	5	6	7	7	39	6.5
Apricot Nectar	100	6	5	8	7	7	8	41	6.8
	70	7	6	9	8	8	8	46	7.7
	35	7	7	9	8	8	8	47	7.8
	0-70	8	7	9	6	8	8	48	8.0
Tomato Juice	100	7	4	5	5	3	8	32	5.3
	70	7	5	7	7	6	8	40	6.7
	35	7	6	8	7	7	9	44	7.3
	0-70	8	6	7	7	7	9	44	7.3
Tapioca Pudding	100	7	3	5	5	4	7	31	5.1
	70	7	5	7	6	6	7	38	6.3
	35	8	6	7	7	7	8	43	7.1
	0-70	8	6	7	8	7	8	45	7.5
Chicken a la King	100	6	4	6	7	4	7	34	5.7
	70	7	5	7	7	5	7	38	6.3
	35	6	6	8	7	5	9	41	6.8
	0-70	7	6	7	7	5	9	41	6.8
Chicken and Rice	100	7	[illegible]	6	6	5	6	35	5.8
	70	7	[illegible]	7	6	6	7	39	6.5
	35	6	7	8	6	7	7	41	6.8
	0-70	7	7	8	6	7	7	42	7.0
Orange Juice	100	8	[illegible]	4	6	4	7	30	5.0
	70	7	5	7	6	6	8	39	6.5
	35	7	7	8	7	7	8	44	7.3
	0-70	7	6	8	8	7	8	44	7.3
Chicken Noodle Soup	100	5	4	4	8	5	7	33	5.5
	70	6	6	7	[illegible]	7	7	40	6.7
	35	6	7	8	7	7	7	42	7.0
	0-70	8	6	8	7	7	7	41	6.8
Beef Barley Soup	100	5	6	5	5	4	6	31	5.1
	70	7	7	7	5	5	6	37	6.1
	35	7	7	8	5	6	7	40	6.7
	0-70	8	7	8	6	6	7	40	6.7
Banana Cream Pudding	100	8	5	6	7	6	7	39	6.5
	70	8	8	7	7	7	8	43	7.3
	35	8	8	7	7	7	8	47	7.8
	0-70	8	8	7	7	7	8	45	7.5
Coffee	100	7	8	8	8	4	6	41	6.8
	70	7	8	8	8	4	7	42	7.0
	35	8	8	9	8	4	7	44	7.3
	0-70	8	8	8	8	4	7	43	7.1
Chili	100	5	4	7	7	4	7	34	5.7
	70	6	6	8	8	4	7	39	6.5
	35	8	7	8	7	5	7	40	6.7
	0-70	7	8	8	8	5	7	41	6.8
Chocolate Pudding	100	8	7	8	7	6	6	43	7.2
	70	8	7	8	7	7	6	44	7.3
	35	8	7	9	7	7	6	45	7.5
	0-70	8	7	8	8	7	6	45	7.5
Cream of Mushroom Soup	100	8	4	6	6	6	7	35	5.8
	70	7	6	6	6	6	8	39	6.5
	35	6	7	7	6	7	8	41	6.8
	0-70	7	6	7	6	7	8	41	6.8
Vegetable Noodle Soup	100	7	6	4	6	6	6	35	5.8
	70	7	7	7	6	6	6	39	6.5
	35	8	7	8	7	7	6	43	7.2
	0-70	8	7	7	7	7	6	42	7.0
Welsh Rarebit	100	7	[illegible]	6	7	3	3	29	4.8
	70	8	5	7	8	6	7	41	6.8
	35	8	5	7	8	6	7	41	6.8
	0-70	8	5	7	8	6	7	41	6.8
Plum Pudding	100	7	8	8	8	8	8	47	7.8
	70	8	9	9	8	8	9	51	8.5
	35	9	9	9	8	8	9	52	8.7
	0-70	8	9	9	8	8	9	51	8.5

TABLE XXXI

COMPARISON OF RATINGS (HEDONIC SCALE) OF SIX AND THREE MONTH PHASE II STORAGE SAMPLES

FOOD BAR SAMPLE	STORAGE TIME AND TEMPERATURE							
	6 mos at 100°F	3 mos at 100°F	6 mos at 70 F	3 mos at 70°F	6 mos at 35°F	3 mos at 35°F	6 mos at 0-70°F	3 mos at 0-70°F
Beef Stew	6.2	6.2	7.2	6.8	7.3	7.0	7.2	6.7
Clam Chowder	5.2	5.7	6.0	6.5	6.7	6.7	6.2	6.3
Shrimp Creole	4.3	6.2	5.5	6.7	6.0	7.5	6.1	6.7
Beef SOS	5.7	6.8	6.3	7.0	6.7	7.2	6.5	6.8
Apricot Nectar	6.8	7.7	7.7	8.0	7.8	8.0	8.0	7.7
Tomato Juice	5.3	6.0	6.7	7.2	7.3	7.7	7.3	7.0
Tapioca Pudding	5.1	7.0	6.3	7.7	7.1	7.7	7.5	7.3
Chicken à la King	5.7	5.8	6.3	6.8	6.8	6.8	6.8	6.7
Chicken and Rice	5.8	5.7	6.5	6.5	6.8	7.0	7.0	6.5
Orange Juice	5.0	6.3	6.5	7.2	7.3	7.3	7.3	7.0
Chicken Noodle Soup	5.5	6.3	6.7	7.0	7.0	7.2	6.8	7.0
Beef Barley Soup	5.1	6.7	6.1	7.3	6.7	7.7	6.7	7.0
Banana Cream Pudding	6.5	7.0	7.5	7.8	7.8	8.3	7.5	8.3
Coffee	6.8	7.2	7.0	7.5	7.3	7.8	7.1	7.5
Chili	5.7	6.0	6.5	6.7	6.7	6.8	6.8	6.7
Chocolate Pudding	7.2	7.8	7.3	8.2	7.5	8.5	7.5	8.2
Crm of Mushroom Soup	5.8	6.3	6.5	6.5	6.8	6.5	6.8	6.5
Veg Noodle Soup	5.8	6.3	6.5	7.2	7.2	7.5	7.0	7.2
Welsh Rarebit	4.8	6.8	6.8	7.5	6.8	7.7	6.8	7.5
Plum Pudding	7.8	8.0	8.5	8.3	8.7	8.5	8.5	8.3

TABLE XXXII

SOLUBILITY READINGS FOR PHASE II FOOD BARS

(Using a Fork to Break Up the Food Bar)

FOOD BAR	MINUTES
Beef Stew	7
Shrimp Creole	5
Chicken & Rice	3
Chili Con Carne	3
Tapioca Pudding	15
Banana Cream Pudding	3
Chocolate Pudding	17
Plum Pudding	6
Beef SOS	12
Chicken à la King	4
Cream of Mushroom Soup	7
Welsh Rarebit	16
Clam Chowder	10
Chicken Noodle Soup	6
Beef Barley Soup	6
Vegetable Noodle Soup	3
Apricot Nectar	14
Tomato Juice	15
Orange Juice	14
Coffee	9

TABLE XXXIII

PENETRATION TESTS OF PHASE II FOOD BARS ON 6-MONTH STORAGE TEST SAMPLES

Flavor	Temp. °F.	Individual Readings (Penetration Value in Millimeters)										Average
Beef Stew	100	80	80	90	70	70	80	70	60	70	60	73.0
	70	80	70	70	80	80	90	70	60	60	70	73.0
	0-70	100	90	100	90	90	90	80	100	90	80	91.0
	35	60	70	70	40	80	60	80	70	80	80	73.0
Clam Chowder	100	20	30	20	40	30	40	40	40	30	30	32.0
	70	30	30	30	40	30	30	40	40	30	40	34.0
	0-70	30	30	30	30	30	30	30	30	30	40	31.0
	35	30	40	30	30	20	30	20	30	20	20	27.0
Shrimp Creole	100	70	80	100	120	90	120	90	100	90	110	97.0
	70	90	90	80	90	90	90	70	80	90	90	86.0
	0-70	100	90	110	90	90	110	120	120	100	100	103.0
	35	80	110	110	80	90	80	90	90	100	110	94.0
Beef SOS	100	60	90	50	60	50	50	50	50	60	50	57.0
	70	40	60	30	50	40	50	70	40	60	50	49.0
	0-70	40	60	30	60	50	60	40	70	60	50	52.0
	35	70	60	60	50	50	50	60	40	70	60	57.0
Apricot Nectar	100	10	20	20	20	20	30	30	10	10	10	18.0
	70	30	30	20	40	40	50	30	40	40	30	35.0
	0-70	40	50	30	40	50	40	30	40	50	40	41.0
	35	30	30	30	30	40	40	20	40	40	50	35.0
Tomato Juice	100	30	10	20	40	30	20	30	20	20	30	27.0
	70	30	30	20	40	40	50	30	40	40	30	35.0
	0-70	40	50	30	40	50	40	30	40	50	40	41.0
	35	30	30	30	30	40	40	20	40	40	50	35.0
Tapioca Pudding	100	30	40	30	30	30	20	20	30	60	30	30.0
	70	40	40	40	30	40	30	30	30	20	30	33.0
	0-70	30	30	30	40	30	30	30	20	30	30	30.0
	35	20	20	20	30	20	20	40	20	30	30	25.0
Chicken a la King	100	50	30	50	40	40	50	60	50	50	60	48.0
	70	70	70	60	70	80	60	50	60	60	60	64.0
	0-70	40	40	30	40	50	40	60	50	50	50	45.0
	35	40	50	60	50	50	50	40	60	50	60	50.0
Orange Juice	100	10	10	10	20	10	10	10	20	10	10	12.0
	70	10	20	30	10	20	20	20	20	30	20	20.0
	0-70	20	10	30	20	20	20	30	20	20	10	20.0
	35	30	20	30	20	20	20	30	30	20	30	25.0
Chicken and Rice	100	50	30	50	40	40	50	60	50	50	60	48.0
	70	70	70	60	70	80	60	50	60	60	60	64.0
	0-70	40	40	30	40	50	40	60	50	50	50	45.0
	35	40	50	60	50	50	50	40	60	50	60	51.0
Chicken & Noodle Soup	100	20	30	20	20	30	30	20	30	20	30	25.0
	70	40	30	40	20	30	40	30	20	40	40	33.0
	0-70	30	20	40	30	30	20	40	30	30	40	31.0
	35	40	50	40	40	30	30	40	50	30	40	41.0
Beef Barley Soup	100	50	50	40	40	30	40	40	50	50	50	40.0
	70	30	40	40	30	40	20	30	40	40	30	34.0
	0-70	50	60	50	30	60	60	50	50	80	50	49.0
	35	50	60	70	70	60	60	50	50	70	60	60.0
Banana Cream Pudding	100	40	40	60	30	50	50	50	50	40	[illegible]	40.0
	70	40	30	[illegible]	50	40	40	20	50	40	[illegible]	[illegible]
	0-70	40	[illegible]	[illegible]	40	[illegible]	[illegible]	[illegible]	20	[illegible]	[illegible]	[illegible]
	35	[illegible]	40	[illegible]	40	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Coffee	100	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	40	[illegible]
	70	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	0-70	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	35	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Chili	100	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	70	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	0-70	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	35	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Chocolate Pudding	100	20	20	[illegible]	20	20	[illegible]	20	20	[illegible]	20	[illegible]
	70	30	30	20	30	30	[illegible]	20	20	30	[illegible]	[illegible]
	0-70	40	40	[illegible]	40	30	30	40	[illegible]	[illegible]	40	[illegible]
	35	30	20	20	10	30	10	10	20	10	30	19.0
Cream of Mushroom Soup	100	40	30	40	40	50	50	30	40	40	40	40.0
	70	40	40	60	50	60	60	40	50	40	40	[illegible]
	0-70	70	70	80	90	80	90	70	70	70	80	77.0
	35	30	60	50	60	60	60	50	40	60	60	53.0
Vegetable Noodle Soup	100	40	30	50	30	40	30	50	40	40	30	38.0
	70	50	40	40	50	50	50	40	40	60	50	47.0
	0-70	70	60	40	60	70	80	80	70	80	70	68.0
	35	60	80	60	60	60	70	70	60	80	70	67.0
Welsh Rarebit	100	40	40	40	40	30	60	40	50	40	30	41.0
	70	50	50	60	60	50	60	60	50	50	40	53.0
	0-70	60	50	60	60	50	50	60	60	50	60	56.0
	35	50	50	40	50	60	60	50	50	50	60	52.0
Plum Pudding	100	20	20	10	30	20	30	30	20	20	20	22.0
	70	40	30	40	40	30	30	30	40	30	50	36.0
	0-70	20	30	40	20	30	40	40	40	50	30	34.0
	35	30	30	40	50	20	30	40	20	30	30	32.0

TABLE XXXIV

DENSITY OF PHASE II FOOD BARS

Food Bars	Density*
Beef Stew	1.09
Clam Chowder	1.06
Shrimp Creole	0.95
Beef SOS	0.97
Apricot Nectar	1.13
Tomato Juice	1.07
Tapioca Pudding	1.13
Chicken à La King	1.01
Chicken and Rice	1.02
Orange Juice	1.36
Chicken Noodle Soup	1.08
Beef Barley Soup	1.00
Banana Cream Pudding	1.25
Coffee	1.06
Chili	.99
Chocolate Pudding	1.65
Cream of Mushroom Soup	.98
Vegetable Noodle Soup	1.29
Welsh Rarebit	1.17
Plum Pudding	1.31

*Grams/cc

FIGURE 1

PHOTOMICROGRAPH OF FREEZE-DRIED MATRIX

FIGURE 2

PHOTOMICROGRAPH OF TRAY-DRIED MATRIX

FIGURE 3

PHOTOMICROGRAPH OF SPRAY-DRIED MATRIX

FIGURE 4

PHOTOMICROGRAPH OF SURFACE OF GRAHAM CRACKER BAR

MADE WITH FREEZE-DRIED MATRIX

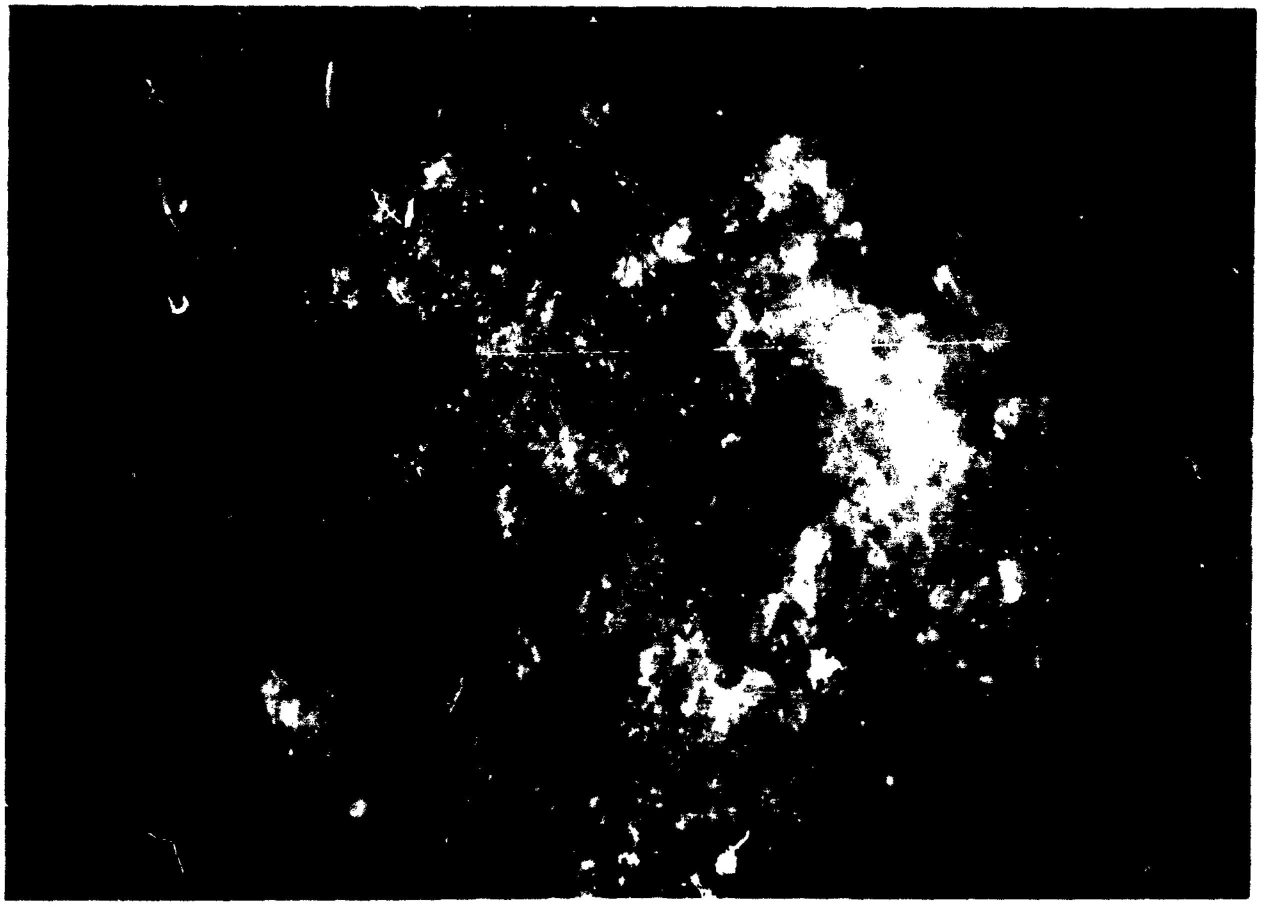


FIGURE 5

PHOTOMICROGRAPH OF SURFACE OF GRAHAM CRACKER BAR

MADE WITH TRAY-DRIED MATRIX

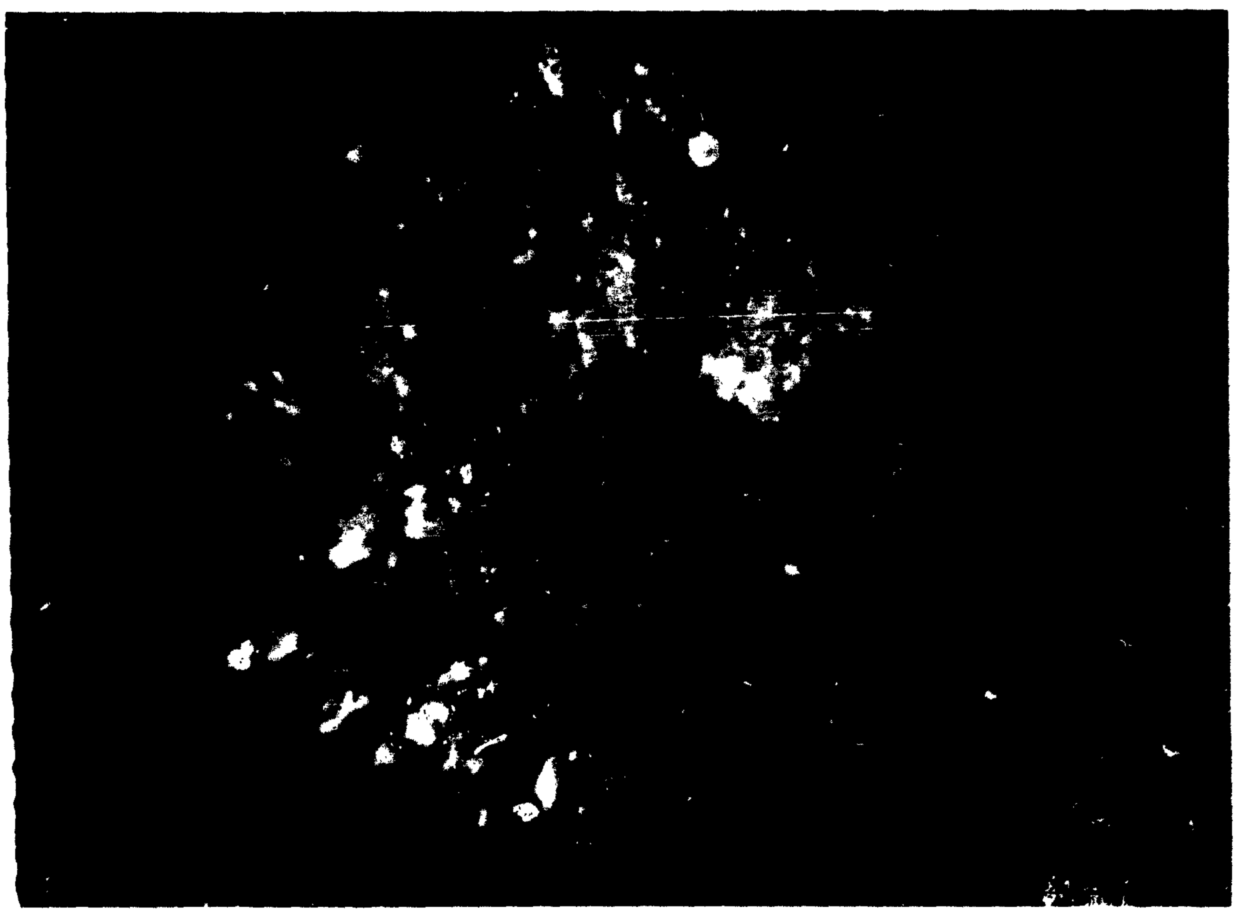


FIGURE 6

PHOTOMICROGRAPH OF SURFACE OF GRAHAM CRACKER BAR

MADE WITH SPRAY-DRIED MATRIX

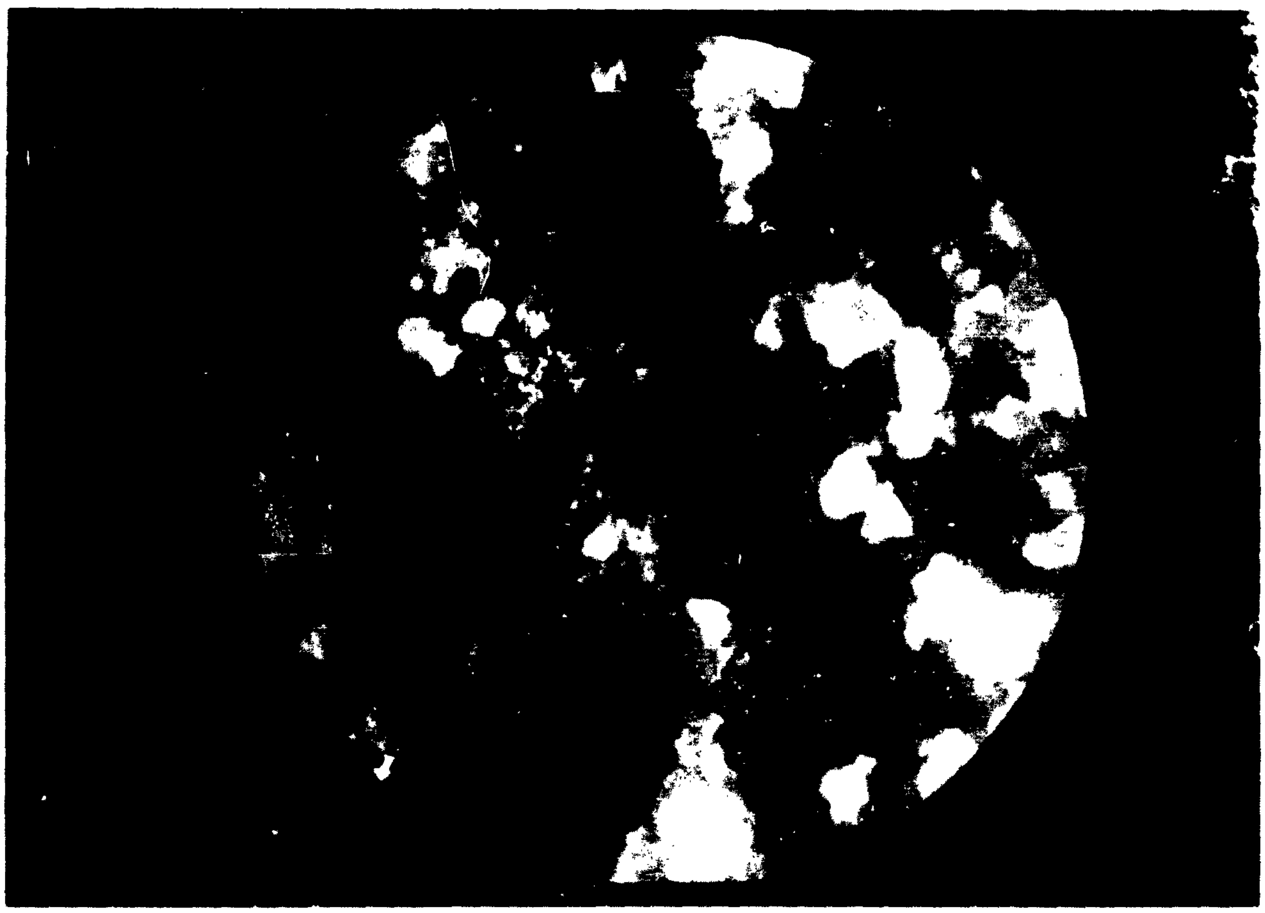
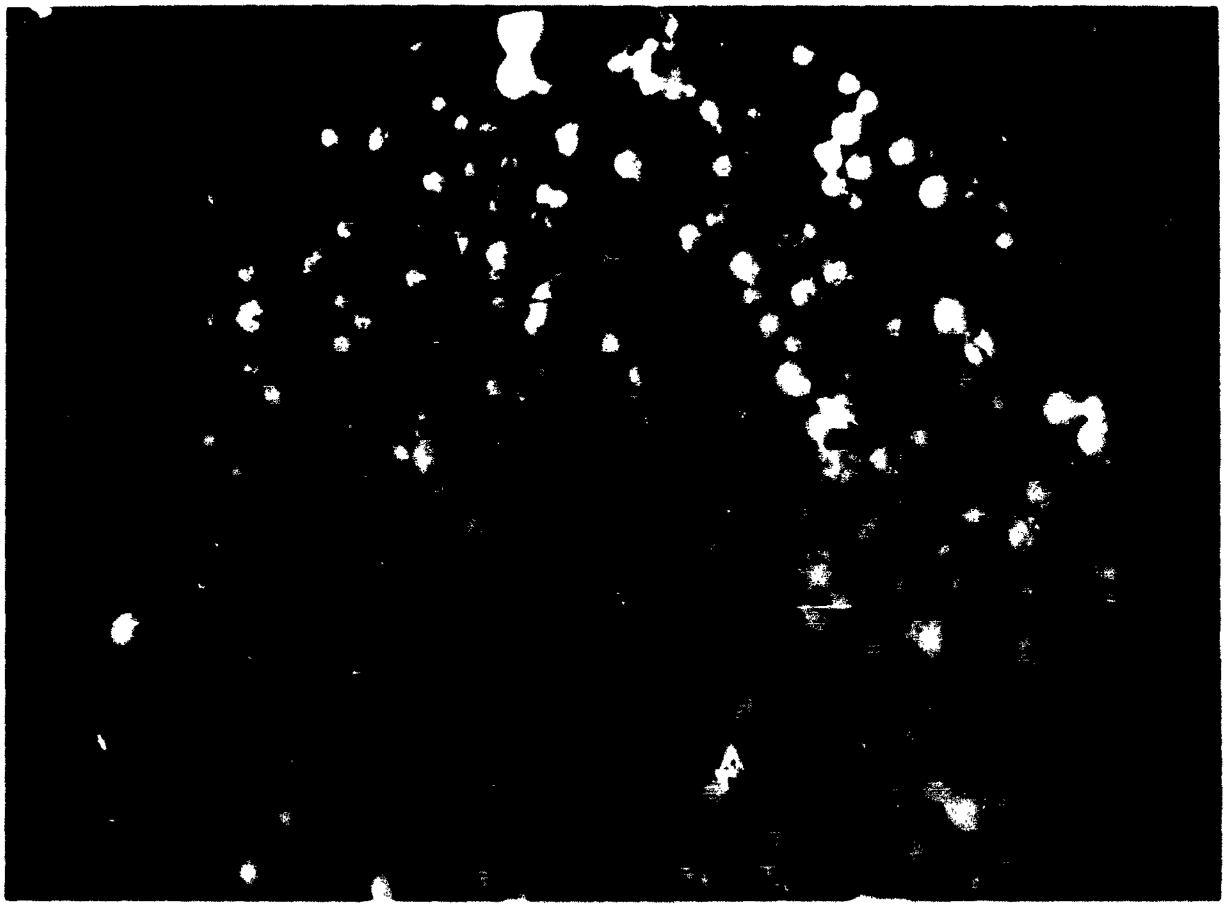


FIGURE 7

PHOTOMICROGRAPH* OF LACTOSE SPRAY-DRIED BY FOREMOST DAIRIES



*Magnification 39x (photograph enlarged)

Unclassified

Security Classification

DOCUMENT CONTROL DATA - R&D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY *(Corporate author)*
Evans Research and Development Corporation

2a. REPORT SECURITY CLASSIFICATION
Unclassified

2b. GROUP

3. REPORT TITLE
ALL-PURPOSE MATRIX FOR MOLDED FOOD BARS

4. DESCRIPTIVE NOTES *(Type of report and inclusive dates)*
Final (17 September 1962- 2 November 1964)

5. AUTHOR(S) *(Last name, first name, initial)*
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6. REPORT DATE
August 1965

7a. TOTAL NO. OF PAGES
70

7b. NO. OF REFS
0

8a. CONTRACT OR GRANT NO
DA19-129-AMC-2111

b. PROJECT NO.
1K643303D548

c.

d.

9a. ORIGINATOR'S REPORT NUMBER(S)
FD-14

9b. OTHER REPORT NO(S) *(Any other numbers that may be assigned this report)*

10. AVAILABILITY/LIMITATION NOTICES
Available at DDC and CFSTI

11. SUPPLEMENTARY NOTES

12. SPONSORING MILITARY ACTIVITY
Animal Products Branch, Food Division,
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13. ABSTRACT

The object of the program was to produce a suitable matrix for various food components (soups, beverages and casseroles) which would not detract from the basic flavor of the major food components. A satisfactory matrix was made from lactose (99%) and sodium carboxymethylcellulose (1%) The matrix can be produced successfully by tray-drying or freeze-drying. This report summarizes the work performed in Phase I and Phase II of the contract and gives the results of the various shelf-life tests. In general, the lactose/carboxymethylcellulose matrix performed well over the broad range of products that were tested.

DD FORM 1 JAN 64 1473

Unclassified

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14. KEY WORDS	LINK A ROLE	LINK A WT	LINK B ROLE	LINK B WT	LINK C ROLE	LINK C WT
Preparation (Formulation)	8					
Matrix	2		9			
Food Bars	2		9			
Lactose	1					
Sodium carboxymethylcellulose	1					
Tray-drying	10					
Spray-drying	10					
Freeze-drying	10					
Storage stability			8			
Cohesion			8			

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