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TECHNICAL REPORT
69-50-FL

DEVELOPMENT OF MOISTURE BINDING MIMETIC AGENTS

by

Frank Hollis, Jr.

General Foods Corporation
White Plains, New York

Contract No. DAAG 17-67-C-0055

March 1969

UNITED STATES ARMY
NATICK LABORATORIES
Natick, Massachusetts 01760

Food Laboratory
FL-81

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FOREWORD

Weight and bulk are major factors in the design of food packets to be carried by the combat soldier during periods when he cannot be resupplied. Freeze-drying of meat and many fruits and vegetables results in highly acceptable products with nutritional values and safety needed. They are light in weight, but have a very low bulk density since there is no significant shrinkage during dehydration. The products can be compressed into bars which are satisfactory for use in food packets. However, due primarily to their low moisture content, most of these bars take up saliva in the mouth more rapidly than it is produced, resulting in extreme dryness sensation.

This investigation attempts to develop and demonstrate agents which will quantitatively reduce the sensation of dryness in compressed freeze-dried foods. The agents used should not markedly affect the flavor of the food nor interfere with rehydration.

The investigation was performed by General Foods Corporation, White Plains, New York. Official Investigator was Frank Hollis, Jr. The investigation was funded under Project No. 1J662708D553, Food Processing and Preservation Techniques, under Contract Number DAAG 17-67-C-0055. Project Officer for U. S. Army Natick Laboratories was Mr. Justin M. Tuomy of the Food Laboratory. Alternate Project Officer was Dr. Donald E. Westcott also of the Food Laboratory.

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ABSTRACT

Moisture mimetic agents and panel techniques have been identified and a bench-top procedure applied to dehydrated compressed food bars to eliminate or reduce the sensation of dryness. Preliminary studies have produced chicken stew, chicken, peas and cereal bars which have the prerequisite cube form, nutrition and reduced dryness when consumed. Sensory taste panel data have shown that the classes: polyhydric alcohols, sugars, fruits, fats and oils exhibit beneficial moisture mimetic properties as additives to compressed dehydrated foods. Rehydration, storage and structural stability tests are reported.

Introduction

Freeze dried foods have contributed greatly in assuring greater mobility and dispersion of combat forces. However, although they provide a substantial reduction in weight, they do not provide a consequential reduction in volume. The development of light weight yet bulky freeze dried foods has led to the investigation of compressed dehydrated food bars. There was concern of the mouth drying characteristics of the food bars when used in direct consumption. Therefore, a project was initiated for the development of moisture binding mimetic agents.

The primary objective of this research effort was to develop edible compositions which, when incorporated into bars prepared by the compression of dehydrated foods, eliminate or markedly reduce the subjective sensation of dryness when consumed as a bar, but which would not significantly impair the hydration characteristics of the food bar.

Primary experimental work was directed towards the development of compressed food bars for direct consumption with secondary emphasis on the rehydration characteristics of the bars. Design limitations of the food bars to be developed are as described below:

1) The dry product is to provide a minimum of 4.0 kilogram calories per gram with a high quality protein content between 20-50% on a dry basis.
2) Fat and ash should not exceed 20% and 1.5% on a dry basis respectively.
3) The edible compositions should not exceed 20% by weight of bar when used with the following classes of foods: combination items, meat and seafood, cereals, fruits, vegetables and dairy items.
4) Bars are to be formed by compression of one ounce of material at pressures below 5000 psi to give a rectangular bar one-half inch thick.
5) Compressed product should be easily sheared by incisors at temperatures between 30° and 100°F and subsequently chewable without becoming crumbly or difficult to swallow.
6) Product should not shatter when dropped on a smooth concrete floor from a height of three feet and should remain dimensionally stable within 10% when held at 100°F for 24 hours under a load of five pounds per square inch.
7) When packaged, it should remain organoleptically acceptable without significant manifestation of chemical, physical or microbiological deterioration throughout three months at 30°, 70° and 100°F.
8) They should rehydrate completely in hot and cold water within 15 minutes with the rehydrated food showing the presence of discrete pieces.

In this manner the bars will serve a dual purpose--direct consumption or rehydrated to yield a familiar food item.

The technical literature has been surveyed to provide a basis for the experimental approaches to the resolution of the assigned technical objectives. A bibliography of pertinent publications has been compiled.

Methods and Materials

Raw Materials

Availability. Freeze dried samples of the six classes of food to be studied were ordered from a wide range of potential suppliers.* Selection of each food class was based on nutrition, wholesomeness, stability, and rehydration characteristics. When developing edible compositions for reducing the subjective sensation of dryness, selection of ingredients was contingent upon the class of food under consideration. All ingredients selected conform to Food and Drug Administration requirements.

Composition. The hydrated and dry composition of classes of food pertinent to this study have been summarized in Table I.

The relatively high ash content (dry basis) of all classes was a matter of concern in the formulation of the food bars. In view of the desired low ash content specified (1.5%), efforts were directed to screening potential mimetic agents with this factor in mind.

Review of Table I indicated that no major technical problems exist from the aspect of achieving the desired caloric density of the finished bar. The wide range in the protein, fat, carbohydrate and fiber of the six classes of food included in this study suggested that more than one combination of ingredients would be necessary to achieve good palatability.

TABLE I

COMPOSITION OF FOODS

Food Item	Item** Number	% Composition on Dry Basis Protein	Fat	CHO	Ash
Chili Con Carne	756	27.1	22.6	43.8	6.5
Chicken - Light Meat	682	87.3	9.4	X	3.3
Beef - Round	353	59.2	33.6	X	7.2
Pork - Ham	1706	74.5	22.4	X	3.1
Fish - Halibut	1104	75.5	20.9	X	3.6
Corn Flakes	866	8.2	0.4	88.7	2.7
Rice Krispies	1884	6.1	0.3	90.6	3.0
Oatmeal	1391	14.9	7.4	71.8	5.9
Fruit Cocktail	1021	3.9	1.0	93.2	1.9
Peaches	1479	5.5	0.9	87.9	5.5
Apricot	30	6.8	1.4	87.0	4.8
Peas, Green	1524	21.9	1.9	71.3	4.8
Corn, Sweet	845	13.6	4.3	80.0	2.13
Cheese, American	653	38.6	50.0	3.2	8.2

*Selection from 1966 Directory of Freeze-Drying published by U.S. Department of Agriculture, Marketing Economics Division - Economic Research Service

**Items described in Composition of Foods, Agriculture Handbook No. 8, U.S. Dept. of Agriculture (Revised December 1963).

Compression

Equipment. A Model B Laboratory Carver Press equipped with a 1-7/8" compression plunger and cylinder was used for the studies. Preliminary studies indicated that one ounce of material when compressed to the desired one-half inch thickness would occupy approximately 2 cubic inches. From the aspect of resistance to fragmentation and overall structural strength, it was postulated that a geometric form approximating a circle would be preferred. Two possible rectangular bar forms were considered: 1) a long sided rectangle approximately 1" x 4" x 0.5", and 2) a square with rounded edges having the approximate dimensions 2" x 2" x 0.5". After consultation with the project officer, it was decided the latter form would be suitable for purposes of the study.

A stainless steel die having the form of a square with rounded edges with dimensions 1-7/8" x 1-7/8" was designed and fabricated of stainless steel stock. This die was used for forming the bars under compression. Appendix A contains detailed drawings of this die.

Dimensional Stability. The compression characteristics of several of the base food categories were studied. Information regarding compression ratios, density changes, pressure-dwell-time requirements and post compression expansion factors for the following items have been surveyed to date:

Corn Flakes
Sugar Coated Corn Flakes
Freeze Dried Cooked Beef Slices
Freeze Dried Cooked Beef Dices
Freeze Dried Cooked Chicken Dices
Dried Apricot Powder
Freeze Dried Peach Slices
Freeze Dried Whole Pea
Freeze Dried Pea Powder

Table II summarizes the compression characteristics of selected classes of some freeze dried chicken, beef, peaches, apricots, peas and conventional corn flakes. These studies indicated that some food classes required the addition of some type of binding or plasticizing agent to permit making dimensionally stable bars at the allowed pressure. Peas, apricots and corn flakes were equilibrated with various levels of water and held sealed in jars at 40°F for 24 hours. It was found that by this simple process it was possible to produce bars which could be handled without exceeding the upper limit of pressure (5000 psi). Fragility and excessive fragmentation were not evident in the case of chicken, beef and peaches.

TABLE II

COMPRESSION CHARACTERISTICS
OF SELECTED FOOD CLASSES

Food Item	% H_2O*	Pressure (psi)	Comments
Post Corn Flakes	7-9	2900-4300	Firm Bar
Chicken, Dices	x	3900-5000	Fragile Bar
Beef Slices	x	2200-5000	Soft Firm
Peach Slices	x	2900	Hard Firm
Apricot Powder	4-9	2500-5000	Hard Firm
Peas Whole	3-10	5000	Fragile

*Minimum water required to form a bar which could be handled without crumbling at slight finger pressure.

Note: All bars compressed to $\frac{1}{2}$" thickness.

It was apparent that the compression characteristics of freeze dried foods could not be predicted from the composition alone, but must be related to other potentially significant factors such as the morphology and rheological properties of these food materials. Other factors such as pre-treatment before drying and particle size may also affect the compression.

Rehydration

Methods. Contract specifications state that the compressed dehydrated bar must rehydrate completely in hot and cold water within 15 minutes with the rehydrated food showing the presence of discrete pieces wherever the starting material consisted of discrete pieces or slices.

Two methods were identified which allowed for the objective measurement of the rate of rehydration as well as percent rehydration of the compressed food bars. These simple techniques appear to be reliable and reproducible.

Details of the capillary test method and a sketch of the apparatus are given in Appendix B of this report. The method was used as an index of the rate of rehydration because of its simplicity and speed while permitting an objective measurement of the rate of rehydration.

Rates of Rehydration. Table III represents a summary of data obtained by the capillary test method in an attempt to generally classify the technical problems to be resolved relative to ease of rehydration of compressed bars.

TABLE III

RATE OF REHYDRATION OF VARIOUS FOOD ITEMS

Material	Description	(mls) H_2O Absorbed* 5 Min.	10Min.	15Min.	Total H_2O Absorbed mls	Comments
Chicken	F.D./Dices	23.1	1.1	0.1	24.3	Hydrated
Beef	F.D./Dices	17.0	0.0	1.6	18.6	Hydrated
Peas	F.D./Whole	6.1	7.2	8.4	21.7	Partial Hydra.
Corn Flakes	Post/Whole	0.5	0	2.2	2.7	Partial Hydra.
Peaches	F.D./Slices	0	0	1.0	1.0	Negligible Hydra.
Apricot	Powder	0	0	0	0	Negligible Hydra.

*Read directly off burette

Note: All samples were pressed to one-half inch thickness in a 1-7/8" cylinder and tested with water at 50°F.

Results of this test indicated the following order of ease of hydration: meat - chicken and beef; vegetables - peas; cereals - cornflakes; and fruit - peaches and apricots. For comparative purposes data from Tables I and III have been assembled into Table IV. This was done in an attempt to correlate compression characteristics with the composition of the foods studied.

TABLE IV

COMPRESSION/COMPOSITION/REHYDRATION CHARACTERISTICS OF FOOD BARS

Food Item	Total H_2O Absorbed (Mls)	% Composition on Dry Basis Protein	Fat	CHO	Ash	Item Number*
Chicken F.D./Dices	24.3	87.3	9.4	-	3.3	682
Beef F.D./Slices	18.6	59.2	33.6	-	7.2	353
Peas F.D./Whole	21.7	22.	1.9	71.3	4.8	1524
Corn Flakes/Post	2.7	8.2	0.4	88.7	2.7	866
Peach F.D./Slices	1.0	5.6	0.9	87.9	5.6	1479
Apricot/Powder	0	6.8	1.4	87.0	4.8	30

Strong capillary forces may explain this order of rehydration. The morphology of these systems may be a greater factor than the actual chemical composition. It appears that the closer a compressed food resembles a sponge, the faster the rate of rehydration. These exploratory studies provided the basis for the following study intended to elucidate methods for accomplishing the required rehydration specifications for the compressed bars.

*All items described in Composition of Foods, Agriculture Handbook No. 8 U.S. Department of Agriculture. (Revised December 1963)

Effect of Selected Additives on Rehydration.

1. Soluble Carbohydrates

Table V demonstrates the beneficial effects of the addition of crystalline sucrose (20% by weight) to corn flakes. The cold water (50°F) capillary test method was used in this experiment.

TABLE V

EFFECT OF SUCROSE ON REHYDRATION OF COMPRESSED CORNFLAKES

Food Item	Ml H_2O Absorbed 5 Min.	10 Min.	15 Min.	Absorbed Ml	Comment
Corn Flake Bar	0.5	0	2.2	2.7	Not completely rehydra.
Corn Flake-Sucrose Bar	26.0	10.7	1.2	37.9	Completely rehydrated

There is a substantial increase in the rate as well as total amount of rehydration of the compressed material. Similar results have been obtained thus far by the use of other soluble carbohydrates such as lactose and low dextrose equivalent corn syrup solids. These studies have provided valuable information relative to selection of moisture mimetic components for foods (meats and poultry) not compatible tastewise with carbohydrates having high sweetening power.

2. High Fat Content Spray Dried Emulsions

Study of the effect of a high fat content spray dried emulsion on the rate of rehydration of a compressed corn flake bar indicated a repression of hydration. Table VI demonstrates the inhibiting effect of the high fat content dry emulsion on cornflakes (20% emulsion and 80% cornflakes.)

TABLE VI

EFFECTS OF HIGH FAT CONTENT SPRAY DRIED EMULSION ON REHYDRATION

Food Item	(mls) H_2O Absorbed 5 Min.	10 Min.	15 Min.	Total Absorbed	Comment
Corn Flake	0.5	0	2.2	2.7	Not completely rehydrated
Corn Flake/ Dream Whip	0	0	0	0	No rehydration

This isolated experiment does not preclude the possibility of obtaining a beneficial effect on the rate of rehydration by use of a spray dried emulsion. The composition of the emulsion, no doubt, has a significant effect on rate of water transfer when the spray dried emulsion is mixed with the base materials.

Screening and Identification of Moisture Agents

This section of the report is concerned with a discussion of the problems to be resolved in the subjective and objective measurement of those food materials which enforce or simulate the effect of added water in the reconstitution of dried materials within the scope of this research. For organizational purpose the research is discussed under three headings:

Sensory Panel Techniques
Summary of Moisture Mimetic Agents Screened
Moisture Mimetic Principles

Sensory Panel Techniques. Based on methodology evolved over a number of years of experience in the sensory evaluation of food products, a panel was selected and oriented in the use of a combined taste/texture profile technique designed specifically for the evaluation of the moisture mimetic quality of compressed dehydrated food bars.

The panel, comprised of four to six members and a leader, was selected on the basis of training, experience and interest in flavor and texture profile methods. Twelve parameters of taste and texture were selected to provide guidelines for a final palatability score. A scale of ten points was established and used in the evaluation of the experimental samples. In each panel session, one control compressed bar (cornflakes and honey) was used as a reference for three experimental bars containing the moisture mimetic agents being evaluated. The panel members evaluated each sample independently and then discussed their responses. The panel leader was responsible for defining and reviewing the objectives of the panel with the moisture mimetic concepts in the foreground of the panel discussions. In addition, the panel leader composited the ratings on each parameter to reflect the average of the individual panelist's judgments.

Parameters of taste and texture chosen to assist the panelists in arriving at a final palatability score are given below:

Initial Moisture	Cohesiveness of Chewed Mass
Hardness	Moistness of Chewed Mass
Plasticity	Dehydration of Mouth
Amount of Salivation	Ease of Swallowing
Crumbliness	After Effect - Thirst

Appendix C of this report contains a tabulation of the terms used by the Sensory Panel and a sample ballot. Definitions of the terms have also been encluded in this section of the Appendix.

Summary of Moisture Mimetic Agents Screened. The scope of this research project did not permit an exhaustive evaluation of all potential moisture mimetic agents at all possible levels. With the assistance of the Product Evaluation Group of the General Foods Technical Center it was possible to organize and screen initially in these categories: (1) carbohydrates, (2) fats and oils, (3) fruit powders, (4) fruit acids, (5) proteins and

(6) emulsifiers, (7) waxes, (8) artificial sweeteners, (9) flavor enhancers, (10) coolants, (11) bittering agents, (12) astringents, (13) spices.

Data from the initial screening of the potential moisture mimetic agents have been tabulated and placed in Appendix D of this report. The findings from the initial screening of these agents as potential moisture mimetic compounds are summarized in the following paragraphs.

1. Carbohydrates

Based on the panel results it appears that carboydrates as a class exhibit varying degrees of effectiveness as moisture mimetic agents. Of twenty four samples initially screened, the following were selected as worthy of further review and consideration: honey, glycerol, glycerol and honey combined and brown sugar. Others which contributed moderately desirable effects were: dextrose, fructose and sorbitol.

2. Fruit Powders

Spray dried fruit powders and drum dried fruits as a class did exhibit desirable moisture mimetic agents. Banana in particular seemed to have the most acceptable overall qualities when tasted from the aspect of a moisture mimetic agent. In addition, the black currant, strawberry and raspberry exhibited the moisture mimetic property. Those fruit powders which contained a relatively high level of citric acid were excessively salivating and left an astringent dehydrated feeling in the mouth. This undesirable effect was due in part to the level of the mimetic agent and no doubt would be eliminated by a reduction in the use level.

3. Fats and Oils

Representative fats and oils were selected for initial screening to determine the effect of this class of materials on the moisture mimetic properties of the bars. These studies indicated the desirable effects of the addition of some fats and oils; some aromatic notes present in certain oils such as olive oil, palm oil and peanut oil can be objectionable and, as a result, the palatability scores were lower than might be expected for fats and oils generally. It was not possible on the basis of this preliminary study to identify any particular oil or fat as being best suited for all classes of foods studied. This area in any future study would have to be expanded in scope to establish firmly the contribution of factors such as the solid/liquid fat index, and the various fatty acid compositions on the overall suitability of the fat or oil on the desired moisture mimetic property.

4. Proteins

Proteins as a class, as predicted, exhibited a very negative effect from the viewpoint of moisture mimetic properties. In general these contributed a dehydrating, tacky and sticky mouthfeel as well as undesirable tastes.

5. Emulsifiers in Oils

Propylene glycol, glyceryl monostearate and lecithin were evaluated for their potential beneficial effects when incorporated in an oil phase. As additives to oils these emulsifiers did not improve the moisture mimetic quality of the oil itself. These preliminary studies, however, could be expanded in the future to gain an insight into the possible beneficial effect of the increase in the monoester content as a possible way of inducing more mimetic properties in oils and fats.

6. Fruit Acids

Preliminary screening of the effect of small levels of citric, malic and tartaric acid indicated that these agents do contribute a significant beneficial effect. As components of fruits which did exhibit good moisture mimetic properties it was not unexpected that the acids commonly found in fruits would contribute to the moisture mimetic effect.

7. Waxes

Of the two samples screened, Carbo-Wax seemed worthy of further study. It was rated higher than the control sample in practically all aspects of a moisture mimetic agent.

8. Sweetner

The artificial sweetner examined, sodium cyclamate, exhibited a very negative effect from the new point of a moisture mimetic agent.

9. Flavor Enhancers

All samples evaluated exhibited a negative effect from the viewpoint of moisture mimetic qualities. Two of the samples, ribotide and mertaste were very dehydrating.

10. Coolants

Both samples, Ice Cream Coolant and menthol, were considered poor as possible moisture mimetic agents. They were very dehydrating and difficult to swallow.

11. Bitter

All 3 samples evaluated, narringen, caffeine, and Chiretta did not improve the eating quality of the control sample and were considered poor as moisture mimetic agents. Due to the high level of bitterness imparted by these agents, any positive characteristics were obscured.

12. Astringent

This sample after chewing, exhibited negative qualities from the standpoint of being a potential moisture mimetic agent. The full drying and burning impact of the astringent agent, Quabracho Extract, was felt as well as a dry mouthfeel and an unpleasant after taste.

13. Spice

Initially, this sample was high in salivation but upon excessive salivation a feeling of dehydration and astringency occurred. The sample was relatively moist but due to the fact that it stuck to the teeth swallowing was difficult. This sample was regarded as a poor moisture mimetic agent.

Moisture Mimetic Principles. Screening of potential moisture mimetic compounds by the Sensory Panel indicated that in general all compounds could be classified into three broad categories: (1) those that tend to increase the subjective impression of moisture, (2) those that decrease the subjective sensation of moisture and (3) those that make no significant positive or negative impression.

For purposes of this study, however, interest was centered only on those compounds which tend to increase the subjective impression of moisture in dehydrated compressed food bars.

The screening studies provided the basis of selection of the materials which would permit formulation of a moisture mimetic composition which in addition to meeting the nutrition requirements would provide the palatability associated with the addition of water to dehydrated foods.

Textural considerations evidently influenced the sensory panel to a significant degree; it is almost impossible for the panelists to consciously differentiate between the taste and textural aspects of the compressed dehydrated bars.

Freeze dried structures apparently provide a desirable stimulus to the mouth in the case of fruits; however, chicken and cottage cheese on the other hand were very unpalatable. In addition to providing lubrication and salivation it was necessary to modify the plasticity of the freeze dried materials. In the latter instance glycerine was found to be the most effective agent for most classes of foods.

The mechanisms of moisture stimulation is far from clearly understood; these exploratory studies have not as yet allowed a classification of data which would permit predicting behavioral patterns for potential moisture mimetic agents. It appears that it will be necessary by trial and error and careful and methodical sensory taste panel techniques to arrive at an understanding of the principles involved in the simulation of moisture in compressed dehydrated foods.

Application of Moisture Mimetic Agents to Various Food Categories

Within the scope of this research contract specification was made that the moisture mimetic compositions be applied to six primary classes of foods as follows:

a. Combination items such as beef stew, chicken stew, chili;

b. Meat and seafood items such as diced or sliced beef, diced or sliced pork, diced or sliced chicken, cooked fish;

c. Cereals such as cornflakes, Rice Krispies, oatmeal;

d. Fruits such as fruit cocktail, peaches, apricots;

e. Vegetables such as peas, beans, corn;

f. Dairy items such as scrambled eggs, cheese.

Concurrent with the screening by the sensory taste panel, studies of potential moisture mimetic agents were initiated to apply those compounds which appeared promising in the early screening.

Representative foods were selected from each of the six classes to be used in conjunction with the moisture mimetic compositions. These were: chicken stew, chicken, Special K, peas, cottage cheese and peaches.

Selected representative foods from each of the six classes specified by the contract were experimentally studied from the aspect of moisture mimetic agent application. A summary of this work is presented below by species under the following related aspects relating to the overall contract requirements:

Raw Materials
Selected Moisture Mimetic Composition
Processing
Sensory Panel Data
Nutritional Comparison
Physical Measurements

Combination Items - Chicken Stew Bar.

1. Raw Materials

Military specification freeze dried chicken stew was ordered from a range of potential suppliers. Since difficulty was encountered in procuring samples, it became necessary to prepare the stew in the laboratory by obtaining and combining the individual freeze dried components (Table VII).

Table VII

Composition of the Chicken Stew Bars (5827-43)

Ingredients (♣)	Grams/Base	% Composition
Freeze Dried Chicken	10.10	44.54
Freeze Dried Stew Sauce (5827-30)	5.99	26.41
Freeze Dried Potatoes	5.21	22.97
Freeze Dried Peas	0.79	3.48
Freeze Dried Carrots	0.59	2.60
Total	22.68	100.00

Table VII (cont)

Chicken Stew Sauce Formulation (5827-30)

Ingredients		% Composition	% Composition on Dry Weight Basis
Spring Water		88.57	X
Instant Non-Fat Dry Milk Solids		3.43	30.00
Tapioca Starch	Prejel	3.43	30.00
Soup Base	Chicken flavor	2.86	25.00
Salt		1.21	10.60
Onion	Dehydrated	0.39	3.40
Pepper	White Ground	0.07	0.60
Just-Rite Seasoning	All-purpose	0.02	0.22
Monosodium Glutenate		0.01	0.09
Garlic Powder		0.01	0.09

Table VIII

Moisture Mimetic Chicken Stew Bar (5827-43)

Ingredients	Grams/Bar	Grams per bar on a Dry Weight Basis	% Composition on a Dry Weight Basis
Precooked Freeze Dried Chicken	10.10	10.10	35.66
Chicken Stew Sauce (Freeze Dried)	5.99	5.99	21.13
Composition I (Whipped Emulsion)	11.40	5.67	20.00
Precooked Freeze Dried Potatoes	5.21	5.21	18.34
Precooked Freeze Dried Peas	0.79	0.79	2.79
Precooked Freeze Dried Carrots	0.59	0.59	2.08
Total	34.08	28.35	100.00

(♣) Freeze dried chicken dices, freeze dried stew sauce, pre-cooked freeze dried potatoes, peas and carrots.

Samples of precooked, freeze dried carrots, potatoes (3/8" dice) and peas were received from California Vegetable Concentrates, Inc. (C.V.C.). Pre-cooked, freeze dried chicken dices were obtained from Henningsen Foods, Inc. The stew sauce was prepared, freeze dried and used in combination with the other stew components as specified in IP/DES S-36-6. (1)

2. Selected Moisture Mimetic Composition

A number of technical problems had to be considered in developing a moisture mimetic composition for this category. A plasticising agent was needed so that compression could be achieved with little fragmentation. Binding agents had to be incorporated in order to increase the dimensional stability of the compressed food bar. Ingredients selected had to fall within the general nutritional requirement levels established by the contract specifications.

The composition developed consisted of a whipped emulsion containing fats/emulsifiers, protein and carbohydrates (Table VIII). When incorporated with the dry chicken stew components it allowed for sufficient plasticization so that little fragmentation occured when compressed into bar form. The protein and carbohydrates greatly aided in forming a dimensionally stable bar.

Table IX

Moisture Mimetic Composition No. I (5827-43)

Ingredients	% Composition	% Composition on Dry Weight Basis
Spring Water	50.25	X
Wecotop "A:	21.35	42.9
Sucrose	15.08	30.3
Propylene glycol Monostearate	5.03	10.1
Sodium Caseinate	4.02	8.1
Wesson Oil	3.77	7.6
Lecithin	0.50	1.0

(1) Packet, Subsistence, Long Range Patrol, No. IP/DES S-36-6 Paragraph 3.3.5.

Table X

Detailed Description of Moisture Mimetic Chicken Stew

Ingredients			% Composition per 1 ounce bar
Freeze dried chicken	Precooked 3/8" dices	Henningsen Foods	35.66
Stew Sauce Mix:	Notebook No. 5827-30	Laboratory Preparation	
Instant Non Fat Dry Milk Solids		Carnation Company	6.34
Tapioca Starch	Prejel	Stein Hall	6.34
Soup Base Chicken Flavor	Good Seasons	General Foods Corp.	5.28
Salt		Red Cross	2.24
Onions	Dehydrated	California Vegetable Concentrates	0.72
Pepper	White ground, No. 204	McCormick	0.13
Just-Rite Seasoning	All purpose	Asmus Broths., Inc.	0.04
Monosodium Glutamate		International Minerals & Mining Co.	0.02
Garlic Powder		Basic	0.02
Moisture Mimetic Composition No. 1:	Notebook No. 5827-43	Laboratory Preparation	
Wecotop "A"		Drew Foods	8.58
Sucrose		Domino	6.06
Propylene glycol monostearate		Wilson Martin Co.	2.02
Sodium Caseinate		Land O' Lakes	1.62
Wesson Oil		Wesson Company	1.52
Lecithin	Centrolene S	Central Soya	0.20
Freeze Dried Potato	Precooked 3/8" dices	California Vegetable Concentrates	18.34
Freeze Dried Peas	Precooked	California Vegetable Concentrates	2.79
Freeze Dried Carrots	Precooked 3/8" dices	California Vegetable Concentrates	2.08

3. Processing

The standard procedure for emulsion preparation as described in the Appendix E was used for preparing the whipped emulsion moisture mimetic Composition No. 1 (Table IX).

A dry blend of the individual chicken stew components was prepared in single bar quantities. The stew sauce was prepared by heating the formulation to a boil for five minutes, freezing it and freeze drying at 120°F shelf heat until all the moisture was removed.

To 22.68 grams of the freeze dried chicken stew mixture, 11.4 grams of the whipped emulsion was added. The sample was mixed and allowed to equilibrate in a sealed container overnight at 40°F.

Compression of this material was accomplished by using a Model B laboratory Carver Press at 2000 psi. for 30 seconds. The press was equipped with a die having dimensions which were previously accepted by NLABS representatives. Preliminary studies indicated that one ounce of material when compressed to the desired one-half inch thickness would occupy approximately 2 cubic inches. A stainless steel die having the form of a square with rounded edges with dimensions 1-7/8" x 1-7/8" was prepared. This die was used for all studies described in this report.

The compressed bar was then quickly frozen and placed in a Stokes Model 21 Freeze Dryer at 120°F shelf heat until the moisture was removed. Detailed description of the bar is given in Table X.

4. Sensory Panel Data

The experimental chicken stew bar was evaluated against a bar prepared by the compression of one ounce of freeze dried chicken stew. This control sample did not contain the moisture mimetic Composition No. I.

Panel results indicated that the experimental bar was a marked improvement over the control in reducing the subjective sensation of dryness. It was more moist initially and when chewed, it was more plastic, easier to swallow and less crumbly and dehydrating.

Palatability ratings, based on a scale of 0-10, were 2.5 for the control and 5.5 for the experimental stew bar.

5. Nutritional Comparison

Table XI

Nutritional Comparison of Moisture Mimetic Stew Bar vs. Requirements

	Chicken Stew Bar grams	/ %	Requirements grams	/ %
Protein	10.6	37.5	5.7-14.2	20-50
Fat	5.91	20.8	0-5.7	0-20
Ash	1.4	5.0	0.-0.43	0-1.5
Calorie	113 total		4 cal/gm	113.4 total

All nutritional requirements, except for ash content, have been satisfied as shown in Table XI.

6. Physical Measurements

Pressures of 2000 psi. for 30 seconds have been identified for preparing reproducible samples with a uniform rectangular cross section of $\frac{1}{2}$ inch.

Objective measurements of the pressures needed to pierce the bar have been conducted.(3) Results indicate that a pressure of 58.7 lbs. is required at 30°F and 37.9 lbs. at 100°F. These data are in agreement with the profile panel results indicating that the bar can easily be sheared by the incisors.

Objective measurements of the bars dimensional stability were made according to the method given in Appendix F.

Bars packaged under vacuum in 4" x 5" metalized polyester pouches were stored at 30°, 70° and 100°F. After 3 months of storage the samples appeared to be in excellent condition with no significant adverse organoleptical changes noted.

Rehydration tests were made according to the methods given in Appendix G. Results of these tests indicated the bars did not rehydrate completely within 15 minutes in either hot or cold water.

Meat and Seafood Items - Chicken Bar.

1. Raw Materials

Samples of various freeze dried meats were ordered from a number of potential suppliers. Satisfactory samples of freeze dried fully cooked 3/8" diced chicken were obtained from Henningsen Foods, Inc. (No. 3707SI). This material was used for all experimental work conducted on this category.

(3) In accordance with procedure given in private communication NLABS Inlabs tim[illegible]: "Texture Measurements on Compressed Foods" 9/1/66.

2. Selected Moisture Mimetic Composition

The moisture mimetic composition developed for this category consists of a whipped emulsion containing gum arabic, Table XII. The fibrous, sandy, straw-like characteristics of the freeze dried chicken appeared to be significantly reduced. This was due to the gum arabic forming a thin film around the chicken fiber thus allowing for ease of swallowing. The addition of fat from the emulsion greatly increased the palatability of the dry, high protein chicken. Formulation is given in Table XIII.

Table XII.

Moisture Mimetic Composition No. II (5827-76-B)

Ingredients		% Composition	% Composition on Dry Weight Basis
Water	Spring	50.25	x
Wecotop "A"		19.58	39.36
Sucrose		11.56	23.24
Gum Arabic		10.55	21.20
Propylene glycol monostearate		3.27	6.57
Sodium Caseinate		2.27	4.57
Wesson Oil		2.02	4.06
Lecithin	Centrolene S	0.50	1.00

Table XIII

Moisture Mimetic Chicken Bar Formulation (5827-76-B)

Ingredients	Gms/Bar	Gms/Bar Dry Weight Basis	% Composition on Dry Weight Basis
Freeze Dried Chicken Dices	22.68	22.68	80.00
Moisture Mimetic Composition No. II	11.40	5.67	20.00
	34.08	28.35	100

Detailed Description of Moisture Mimetic Chicken Bar

Ingredients

Freeze Dried Chicken Precooked 3/8" Dices	Henningsen Foods	80.00
Wecotop	Drew Foods	6.76
Sucrose	Domino	4.78
Gum Arabic	Stein Hall Co.Inc.	4.23
Propylene glycol monostearate	Wilson Martin Co.	1.59
Sodium Caseinate	Land O'Lakes	1.28
Wesson Oil	Wesson Co.	1.20
Lecithin Centrolene S	Central Soya	0.16

3. Processing

The standard emulsion preparation procedure was used for preparing the moisture mimetic Composition No. II. The gum arabic was dispersed in the sugar/sodium caseinate mixture and added to water and homogenized in the Waring Blendor.

11.4 grams of the whipped emulsion was added to 22.68 grams of freeze dried chicken. The sample was mixed well and equilibrated in a sealed container at 40°F for four hours.

The Bar was formed by compression of the equilibrated chicken in the chilled stainless steel die at 2000 psi. for 30 seconds. The compressed bar was quickly frozen and freeze dried at 120°F shelf heat.

4. Sensory Panel Data

The experimental chicken bar was evaluated against a bar prepared by the compression of one ounce of freeze dried chicken dices. This control sample did not contain the moisture mimetic Composition No. II.

Panel results indicate that the experimental prototype was better than the control on all moisture mimetic qualities. It was more moist, plastic and cohesive and less crumbly and dehydrating than the control. It did, however, contain hard pieces and was therefore slightly difficult to chew. It was considered to be slightly too high in sweetness and too low in chicken flavor.

Palatability ratings were 3.0 for the control and 5.0 for the experimental prototype.

5. Nutritional Comparison

Table XIV

Nutritional Comparison of Moisture Mimetic Stew Bar vs. Requirements

	Chicken Bar grams	/ %	Requirements grams	/ %
Protein	19.2	67.7	5.7-14.2	20-50
Fat	5.9	20.8	0-5.7	0-20
Ash	0.8	2.8	0-.43	0-1.5
Calorie	136.		4 cal/gm	113.4 total

The nutritional picture for the chicken bar is presented in Table XIV. The protein content exceeds the protein requirement range solely based on 22.68 grams of freeze dried chicken. Therefore, when supplemented with additional ingredients, the protein content is even further increased.

6. Physical Measurements

Reproducible samples uniformly $\frac{1}{2}$ inch thick are attained by compression at 2000 psi. for 30 seconds.

Pressures of 55.7 lbs. at 30°F and 33.9 lbs. at 100°F are required to shear the bar. These objective data indicate that the product can easily be sheared by the incisors at these temperatures.

Objective measurements of the bars dimensional stability were made according to the method given in Appendix F.

Bars packaged under vacuum in 4" x 5" metalized polyester pouches were stored at 30°, 70° and 100° F. After 3 months of storage the samples were judged to be excellent from a quality aspect.

Rehydration tests were made on the bars according to the method given in Appendix G. Results of these tests indicated the bars rehydrated completely into discrete pieces within 15 minutes in both hot and cold water.

Cereal Item - Special "K"

1. Raw Material

The availability of suitable representative items for this category presented no problem. Kellogg's Special "K" was selected upon evaluating numerous ready-to-eat cereals as to their nutrition, wholesomeness, texture and rehydration characteristics.

2. Selection of Moisture Mimetic Composition

The moisture mimetic composition developed for this category (Table XV) allowed for supplementing protein into the Special "K". It contributed a strong binding property as well as a plasticizing effect to insure little fragmentation upon compression.

The composition consisted of a high protein whipped emulsion. When mixed with the Special "K" cereal, it produced a tacky surface which permitted the addition of powdered sucrose to adhere to the surface of each flake. Upon redrying, the sucrose is present in crystalline form thus producing a cooling effect on the tongue when eaten.

Table XV

Moisture Mimetic Composition No. III (5827-54)

Ingredients	%Composition	% Composition on Dry Weight Basis
Water	61.61	X
Wecotop "A"	13.87	36.11
Sodium Caseinate	9.78	23.48
Sucrose	8.68	22.61
Propylene glycol monostearate	3.27	8.53
Wesson Oil	2.46	6.42
Lecithin Centrolene S	0.33	0.85

Table XVI

Moisture Mimetic Cereal Bar Formulation (5827-55-BI)

Ingredients	Gms/Bar	Gms/Bar Dry Weight Basis	% Composition on Dry Weight Basis
Special "K"	22.68	22.68	80.00
Moisture Mimetic Composition No. III	12.92	4.96	17.50
Sucrose, powder	0.71	0.71	2.50
	36.31	28.35	100.00

Detailed Description of Moisture Mimetic Cereal Bar

Ingredients		% Composition
Special "K"	Kellogg Co.	80.00
Sucrose	Domino	6.46
Wecotop "A"	Drew Foods	6.32
Sodium Caseinate	Land O' Lakes	4.46
Propylene glycol monostearate	Wilson Martin Co.	1.49
Wesson Oil	Wesson Co.	1.12
Lecithin Centrolene S	Central Soya	0.15

3. Processing

Formulation of the cereal bar is given in Table XVI. The standard procedure for emulsion preparation was used for preparing the whipped emulsion moisture mimetic Composition No. III.

To 22.68 grams of the Special "K", 12.92 grams of the moisture mimetic Composition No. III was added. Sample was mixed well, until the whipped emulsion was no longer noticeable.

0.7 grams of powdered sucrose was then carefully sprinkled onto the mass, and mixed periodically to insure even dispersion. Sample was equilibrated in a sealed container at 40°F for 2-½ hours.

Compression of the equilibrated cereal was accomplished in the chilled stainless steel die at 2000 psi. for three minutes. The sample was quickly frozen on dry ice and then freeze dried at 120°F shelf heat until all the moisture was removed.

4. Sensory Panel Data

The experimental cereal bar was evaluated against a control bar prepared by the compression of one ounce of Special "K". In order to prepare a dimensionally stable control bar, it was necessary to equilibrate the cereal with 8% water, press into bar form and freeze dry.

5. Nutritional Comparison

Table XVII

Nutritional Comparison of Moisture Mimetic Cereal Bar vs. Requirements

	Cereal Bar grams / %		Requirements grams / %	
Protein	5.80	20.5	5.7-14.2	20-50
Fat	2.84	10	0-5.7	0-20
Ash	X		0-0.43	0-1.5
Calorie	121 total		4 cal/gm	113.4 total

All the nutritional requirements have been met as indicated in Table XVII.

6. Physical Measurements

Reproducible samples $\frac{1}{2}$ inch thick are attained by compression at 2000 psi. for 3 minutes.

Pressures of 95.7 lbs. at 30°F and 88.8 lbs. at 100°F are required to pierce the bars. These results indicate that moderate pressures would be required to shear the bar with the incisors.

Objective measurements of the bars dimensional stability were made according to the method given in Appendix F.

Bars packaged under vacuum in 4" x 5" metalized polyester pouches were stored at 30°, 70° and 100°F. After 3 months of storage the bars appeared to be in excellent condition.

Rehydration tests were made on the bars according to the method given in Appendix G. Results of these tests indicated the bars rehydrated completely into descrete pieces within 15 minutes in both hot and cold water.

Vegetables - Peas

1. Raw Materials

Samples of precooked freeze dried peas were obtained from California Vegetable Concentrates, Inc.

2. Selected Moisture Mimetic Composition

The development of a moisture mimetic composition (Table XVIII) for this category consisted of two phases. The first phase involved treating the freeze dried peas with glycerin. This treatment served two purposes in that the glycerin functioned as a plasticizing agent permitting compression of the freeze dried peas with little fragmentation. Similarly, it aided in softening the individual peas in the dry moisture mimetic bar.

The second phase consisted of treating the glycerinated peas with the moisture mimetic Composition No. I. This whipped emulsion greatly aided in forming a dimensionally stable bar as well as contributing towards reducing the sensation of dryness.

Formulation of pea bar is given in Table XIX.

Table XVIII

Moisture Mimetic Composition No. IV.

Ingredients	% Composition	% Composition on Dry Weight Basis
Moisture Mimetic Composition No. I	88.46	80.07
Glycerin/H_2O	10.96/0.58	19.93/X

Table XIX

Moisture Mimetic Pea Bar (5858-11)

Ingredients	Gms/Bar	Gms/Bar on Dry Weight Basis	% Composition on Dry Weight Basis
Freeze Dried Peas	22.68	22.68	80.00
Moisture Mimetic Composition No.I	9.13	4.54	16.01
Glycerin	1.19	1.13	3.99

Detailed Description of Moisture Mimetic Pea Bar

Ingredients		% Composition
Freeze Dried Peas Precooked	California Vegetable Concentrates	80.00
Wecotop "A"	Dreq Foods	6.87
Sucrose	Domino	4.84
Glycerin	Baker Chemical Co.	3.99
Propylene glycol monostearate	Wilson Martin Co.	1.62
Sodium Caseinate	Land O' Lakes	1.30
Wesson Oil	Wesson Co.	1.22
Lecithin Centrolene S.	Central Soya	0.16

3. Processing

The moisture mimetic Composition No. I was prepared as previously described.

1.19 ml. of (95%) glycerin was heated to 180°F and sprayed onto 22.68 grams of precooked freeze dried peas tumbling in a stainless steel coating bowl. Sample was equilibrated at ambient room temperatures in a sealed container for 20 hours.

The glycerinated peas (23.87 gms) were then treated with 9.13 grams of the whipped emulsion moisture mimetic Composition No. I. Sample was equilibrated in a sealed container for three hours at 40°F.

The peas were compressed at 2000 psi. for 30 seconds in the chilled stainless steel die. The bar was quickly frozen on dry ice and freeze dried at 120°F shelf heat.

4. Sensory Panel Data

The experimental pea bar was evaluated against a control bar prepared by the compression of 1 ounce of freeze dried peas. It was necessary to equilibrate the freeze dry peas with 8% water and redry in order to form a dimensionally stable control bar.

Panel results indicate that although the experimental bar was more moist initially and slightly better on all moisture qualities, it was still considered hard and fairly crumbly when chewed, stuck to the teeth and was difficult to swallow.

Palatability ratings were 1.0 for the control and 2.5 for the experimental.

5. Nutritional Comparison

Table XX.
Nutritional Comparison of Moisture Mimetic Pea Bar vs. Requirements

	Pea Bar grams/	%	Requirements grams/	%
Protein	6.97	24.6	5.7-14.2	20-50
Fat	5.5	19.4	0-5.7	0-20
Ash	0.83	3.0	0-0.43	0-1.5
Calorie	127		4 cal/gm	113.4 total

All nutritional requirements, except for the ash content, have been satisfied, as indicated in Table XX.

6. Physical Measurements

Reproducible samples with a rectangular cross section uniformly ½ inch thick are prepared by compression at 2000 psi. for 30 seconds.

Objective measurement of the pressures needed to pierce the bar were 76.3 lbs. at 30°F and 68.5 lbs. at 100°F. This indicates that the bars can easily be sheared by the incisors.

The dimensional stability of the bars was tested according to the procedure given in Appendix F.

Bars packaged under vacuum in 4" x 5" metalized polyester pouches were stored at 30°, 70° and 100°F. The condition of these bars after 3 months of storage was excellent.

Rehydration tests were made on the bars according to the method given in Appendix G. These bars completely rehydrated into discrete pieces within 15 minutes in both hot and cold water.

Dairy - Cottage Cheese

1. Raw Materials

Creamed, freeze dried cottage cheese, obtained from the Post Division of General Foods Corporation was used in the studies.

2. Selected Moisture Mimetic Composition

A moisture mimetic composition has not been identified which is considered suitable for this category. Bars containing potential moisture mimetic agents therefore were not panel profiled nor placed in storage. Direction for future studies in this category resulted from these explorations (Table XXI).

Various fruit flavored drinks as well as one vegetable flavored drink were evaluated as possible moisture mimetic agents in the formulation of a cottage cheese bar. The fruit and vegetable juices were selected on the basis of their compatibility with cottage cheese. The juices selected were: Tang, Start, Awake, peach nectar, apricot nectar and V-8 vegetable juice. The composition ratio of cottage cheese to juice was 80/20. Tang was also evaluated at a 70/30 ratio. The Tang-Cottage Cheese sample (70%/30%) appeared to have more advantages than the other samples at a 20% level. The Tang sample at the 20% level was considered inadequate. The best flavored drink at 20% level was Start but it still did not compare with Tang at a 30% level. The excess acid taste was beneficial since it caused salivation, the orange flavor was very palatable with the cottage cheese and it appeared that gum arabic helped eliminate the chalky character of the compressed cottage cheese.

TABLE XXI

COTTAGE CHEESE - MOISTURE MIMETIC AGENTS

BASE	MIMETIC AGENT	COMPOSITION (gms) BASE (dry basis)	COMPOSITION (gms) MIMETIC AGENT (dry basis)	PROCESS OUTLINE	COMMENTS
Freeze Dried Cottage Cheese	Control	28.35		compress	chalky, dry
" "	Tang	22.68	5.67	dry blend/compress	sl. salivating gummy, acidic
" "	Tang	19.84	8.51	" "	"
" "	Start	22.68	5.67	" "	"
" "	Start	19.84	8.51	" "	"
" "	Awake	22.68	5.67	Homogenize/freeze dry compress	"
" "	V-8	22.68	5.67	" "	"
" "	Peach Nectar	22.68	5.67	" "	"
" "	Honey	22.68	5.67	" "	"
" "	Apricot Nectar	22.68	5.67	" "	"
" "	Gum arabic	28.00	0.35	" "	less chalky

Note: In all cases the experimental samples were preferred over the control; however, the high acid content, and the gummy nature of the samples strongly suggested that cottage cheese should be substituted with a much blander (less acidic) dairy cheese.

In general it appears that the combination of fruit and cheese may result in a satisfactory bar; considerable further work must be done in this category to arrive at a bar meeting all the requirements set forth.

3. Processing

Processing techniques have not been identified.

4. Sensory Panel Data

Product profile panel evaluations have not been made.

5. Nutritional Comparison

Since a satisfactory bar has not been identified; nutritional data has not been provided. This aspect will not present any difficulty because of the excellent nutritional quality of the base.

6. Physical Measurements

No physical measurements have been conducted.

Fruits - Peaches

1. Raw Materials

Due to the difficulty encountered in obtaining satisfactory samples of freeze dried peaches it was necessary to prepare a small quantity of freeze dried peaches.

Peaches obtained at a local market were washed, sliced (1/8" slices), soaked for one minute in 1% water solution of ascorbic acid and then dipped in a 0.01% water solution of sodium bisulfite. After draining the slices were frozen at minus 30°F overnight and freeze dried.

The quality of these freeze dried peaches was considered excellent and were selected for use in our experimental studies in this category.

2. Selected Moisture Mimetic Composition

Limited experimental studies have been conducted in this category. Analytical data for peaches indicated it would be necessary to supplement this base with added protein in order to satisfy the nutritional requirements.

Preliminary indications were that a combination of fruit with cheese should result in a good tasting product. Subsequent studies indicated that although a reconstituted mixture of cottage cheese and peaches is quite delectable this did not hold true for the dried compressed combination.

Freeze dried peaches which are not compressed are quite palatable; compression, however, renders them much less palatable. This loss in palatability may be due in part to the relatively high concentration of acid resulting from the change in the density of the product. In addition, it appears that the pectinous nature of the peach adds an undesirable gummy quality to the freeze dried compressed product.

A preferred moisture mimetic composition has not been identified for this category. Bars containing moisture mimetic agents have not been profiled nor were they subjected to storage studies.

Exploratory studies conducted in the area of fruits as exemplified by peach slices may shed some light on the problems to be resolved prior to identification of a satisfactory compressed moisture mimetic fruit bar.

Studies made in this category are shown in Table XXII.

Efforts were made to examine the relative ease of hydration of the bars as well as the overall taste qualities.

The effect of sucrose on freeze dried peach slices was studied in the range of 20% to 50% with no significant improvement in the eating quality of rehydration properties.

Combinations of peach fines and peach slices did not improve the taste or rehydration ability of the bar. Other agents investigated included wet and dry emulsions, fresh cottage cheese and dried cottage cheese rehydrated in a mixture of glycerine and water. All attempts were unsuccessful in that the compressed bar lacked rehydration capability and were generally gummy and unpalatable.

TABLE XXII

PEACHES - MOISTURE MIMETIC AGENTS

BASE	MIMETIC AGENT	COMPOSITION (GMS.) DRY BASIS) BASE	MIMETIC AGENT	PROCESS	COMMENT
Freeze dried Peaches 1/8" slices	control	28.35	-	compress	very acidic and very gummy
"	sucrose	22.68	5.67	dry blend compress	very acidic and very gummy
"	"	19.84	8.51	"	slight improvement over control
"	"	14.18	14.17	"	slight improvement over control
"	peach fines	22.68	5.67	"	similar to control
"	" "	14.18	14.17	"	similar to control
"	Dream Whip (dry emulsion)	22.68	5.67	"	gumminess is still objectionable
"	" "	14.18	14.17	"	gumminess is still objectionable
"	Dream Whip (reconstituted)	22.68	5.67	equilibrate compress	gumminess is still objectionable
"	Freeze dried cottage cheese glycerine/water	14.18	14.17	freeze dry	gumminess is still objectionable
"	"	22.68	5.67	" "	gummy and acidic
"	"	14.18	14.17	" "	" "
"	Fresh Cottage Cheese	22.68	5.67	" "	gummy and acidic
"	"	14.18		" "	gummy and acidic

3. Processing

Since a satisfactory compressed fruit bar meeting minimum requirements was not formulated a processing method is not given.

4. Sensory Panel Data

Compressed fruit bars were not subjected to panel studies.

5. Nutritional Comparison

Formal nutritional comparisons of various experimental bars containing fruit have not been included in this report. It is evident that a protein supplement will be necessary to bring this base into the desired range of nutrition.

6. Physical Measurements

Physical measurements were not made on these bars; none were considered at a level of acceptability that would warrant these studies.

Moisture Mimetic Composition and Process Compared.

Table XXIII provides a comparison of four categories from the aspect of the moisture mimetic compositions and processes for producing the compressed bars at benchtop.

TABLE XXIII

MOISTURE MIMETIC COMPOSITION AND PROCESSES FOR SELECTED FOOD CLASSES

Food Categories	Base	Moisture Mimetic Comp.	Process
Combination Items Chicken Stew	Precooked Freeze Dried Diced Chicken Chicken Stew Sauce (Freeze Dried) Precooked Freeze Dried Diced Potato Precooked Freeze Dried Peas Precooked Freeze Dried Carrots	Wecotop "A" Sucrose Propylene Glycol-Monostearate Sodium Caseinate Wesson Oil Lecithin, Centrolene-S	Prepare and freeze dry the Chicken Stew Sauce Prepare whipped emulsion Add whipped emulsion to a blend of base material Compress into bar form Freeze dry
Meat/Seafood Item Chicken	Precooked Freeze Dried Diced Chicken	Wecotop "A" Sucrose Gum Arabic Propylene Glycol-Monostearate Sodium Caseinate Wesson Oil Lecithin, Centrolene-S	Prepare whipped emulsion Add to freeze dried chicken Compress to bar form Freeze dry
Cereals Special "K"	Special "K" Cereal	Sucrose Wecotop "A" Sodium Caseinate Propylene Glycol-Monostearate Wesson Oil Lecithin, Centrolene-S	Prepare whipped emulsion Add to the Special "K" Sprinkle on powdered sucrose Compress into bar form Freeze Dry
Vegetables Peas	Precooked Freeze Dried Peas	Wecotop "A" Sucrose Glycerin Propylene Glycol-Monostearate Sodium Caseinate Wesson Oil Lecithin, Centrolene-S	Spray freeze dried peas with glycerin Prepare whipped emulsion Add emulsion to glycerinated peas Compress to bar form Freeze dry

Nutrition And Sensory Panel Preference For Selected Moisture Mimetic Bars Having the Required Cube

Table XIV summarizes the nutrition and sensory panel preference for the moisture mimetic bars.

TABLE XXIV

NUTRITION - CONSUMER PREFERENCE - CUBE FOR SELECTED FOOD CATEGORIES

Items	Gen. Quality-Palatability Rating (C-10 scale)							
	Control	Experimental	Target:	Protein 5.67-14.18	Fat 5.67	Ash 0.43	Cal. 4/Gm	Cube
Chicken Stew	2.5	5.5		10	6	1.4	4	Satisfactory
Chicken	3.0	5.0		19	6	0.8	5	Satisfactory
Special "K"	3.5	6.5		6	3	-	4	Satisfactory
Peas	1.0	2.5		7.0	6	0.8	5	Satisfactory

Incisor Penetration and Rehydration Characteristics For Selected Moisture Mimetic Bars

The comparison of incisor penetration and rehydration qualities of four selected moisture mimetic bars is given in Table XXV.

TABLE XXV

INCISOR PENETRATION - REHYDRATION CHARACTERISTICS FOR SELECTED FOOD CATEGORIES

Items	Incisor Penetration (lbs)		Rehydration	
	30°F	100°F	Cold	Hot
Chicken Stew	58.7	37.9	Poor	Poor
Chicken	55.7	33.9	Very Good	Satisfactory
Special "K"	95.7	88.8	Poor	Poor
Peas	76.3	68.5	Satisfac-tory	Satisfactory

Storage Studies

Storage Characteristics of Selected Food Classes

Storage studies of the compressed food bars of four classes represented by the chicken stew, chicken, cereal and pea bars are summarized in the following Table XXVI. Results represent storage of these moisture mimetic bars for a period of three months at various temperatures.

TABLE XXVI

STORAGE (THREE MONTHS) CHARACTERISTICS OF SELECTED FOOD CLASSES AT 30°F, 70°F and 100°F

Item	30°F			70°F			100°F		
	Color	Flavor	Odor	Color	Flavor	Odor	Color	Flavor	Odor
Chicken Stew	Normal	Clean	Clean	Normal	Clean	Clean	Normal	Clean	Clean
Chicken	"	"	"	"	"	"	"	"	"
Special "K"	"	"	"	"	"	"	"	"	"
Peas	"	"	"	"	"	"	"	"	"

Examination of the data tabulated in the above Table XXVI indicated a favorable forecast for the ultimate shelf life of moisture mimetic compressed bars in the classes examined. Though bacteriological data is not available the overall appearance and taste of the stored products indicated no apparent problem in this regard.

Shatter Test of Storage Samples

A relatively simple test was divised to measure the shatter properties of the bars containing the moisture mimetic agents. Details of this method are included in the Appendix F. Four classes of food bars represented by the chicken stew, chicken, cereal and pea bars were stored at various temperatures for a period of three months. The test was conducted on the bars after removing them from storage. In all cases the packaging material was removed so that the falling weight impacted directly on the center of the exposed bar.

TABLE XXVII

SHATTER TEST OF SELECTED FOOD AFTER STORAGE THREE MONTHS AT 30°F, 70°F and 100°F

Item	30°F	70°F	100°F
Chicken Stew	(4)	(4)	(4)
Chicken	(1)	(1)	(1)
Special K	(4)	(4)	(4)
Peas	(1)	(1)	(1)

Note: # in bracket indicates the number of falls required to cause the unwrapped bar to shatter.

Though correlations of these test data with actual test performance is not available it was felt that the test provided a good index of the shatter characteristics of the bars. From this simple test it was predicted that the bars tested have good shatter characteristics and could withstand considerable handling and shock without crumbling. When packaged it would appear that this physical property would be further enhanced.

SUMMARY

This is the final report of the work directed to the development, testing and demonstration of edible compositions which incorporated in compressed dehydrated food bars eliminate or markedly reduce the sensations of dryness while not significantly impairing the hydration characteristics of the bars.

Sensory panel techniques have been effectively utilized in screening and identification of moisture mimetic agents as additives to compressed food bars. These studies support the premise that certain compounds when tasted alone or in combination do exhibit moisture mimetic properties.

Compounds in the following food categories have been shown by sensory panel testing to be effective moisture mimetic agents: polyhydric alcohols, sugars, fruits and fats and oils. Further study will be required to quantify the relative effectiveness of the various agents in each category in terms of compatability for each of the classes of foods within this study.

An emulsion technique has been identified which permits the effective incorporation of the moisture mimetic agents into the base food materials. Four mimetic compositions suitable for the dehydrated compressed bars were successfully incorporated by the emulsion technique.

The sensory taste panel preferred the chicken stew, chicken meat, cereal and pea bars containing the moisture mimetic agents over the counterparts without the added moisture mimetic agents. A universal moisture mimetic composition has not been identified which is suitable for all classes of foods within the scope of the study. The nutritional requirements promulgated for the various classes of foods precludes this accomplishment.

Compression studies using specially designed stainless steel dies were carried out which indicated the desired tube structural stability. Nutrition and shelf life can be achieved for the moisture mimetic chicken stew, chicken, cereal and pea bars.

Moisture mimetic compositions suitable for the dairy and fruit classes have not been identified; however, initial studies in these areas suggest pre-treatment of the base prior to freeze drying may result in excellent moisture mimetic bars.

Compressed bars of all classes have been rehydrated in studies designed to shed light on the factors affecting the rehydration of these bars. These studies have shown that addition of soluble carbohydrates when mixed with the freeze dried major components of the compressed bars, significantly increased the rate of rehydration.

Included in this report are descriptions of raw materials, formulas, processing descriptions, panel data, nutritional comparisons and physical measurements completed in the categories: combination items, meat and seafood items, cereal items and and vegetables. The Appendix contains summary tables of the sensory panel data, a sample panel ballot, definitions of panel terminology, rehydration, and shatter test methods, a description of the compression die, and a description of the benchtop process for making the whipped emulsion.

A bibliography of pertinent background data is also included.

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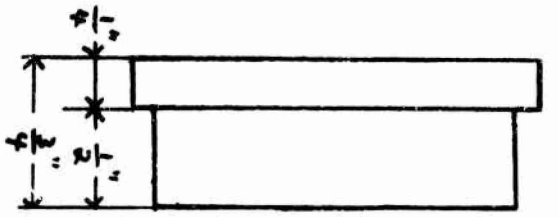
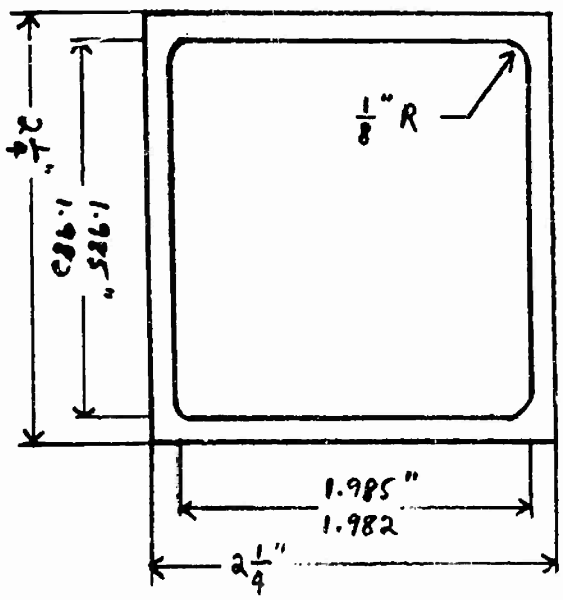
APPENDIX A

Blueprint of Compression Die Used in Studies on Compressed Moisture Mimetic Food Bars





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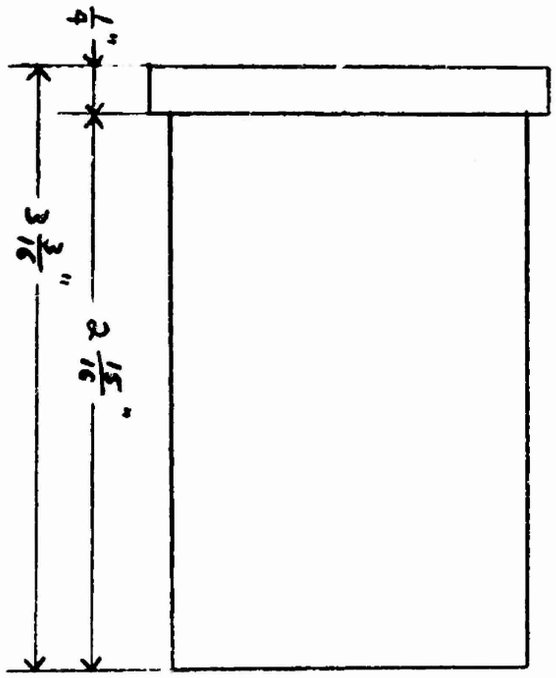

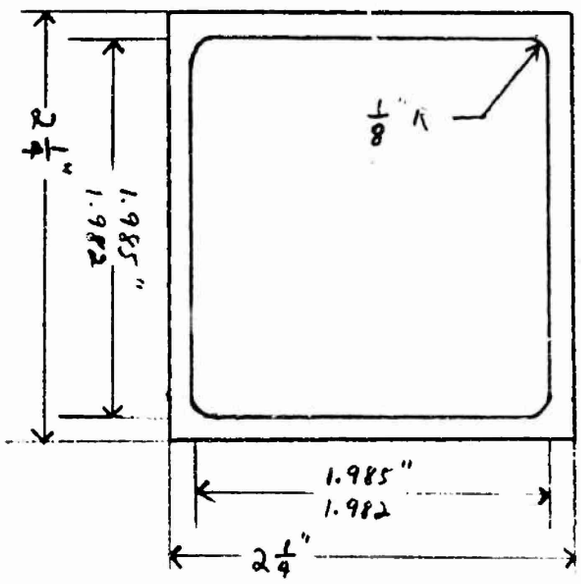

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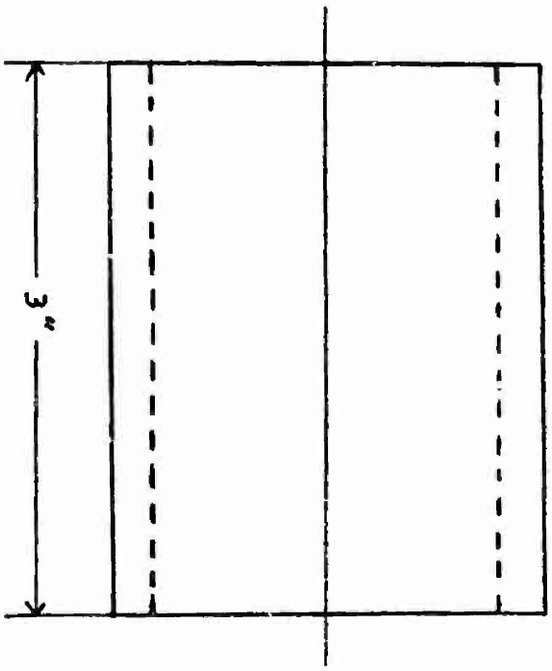

TUBE

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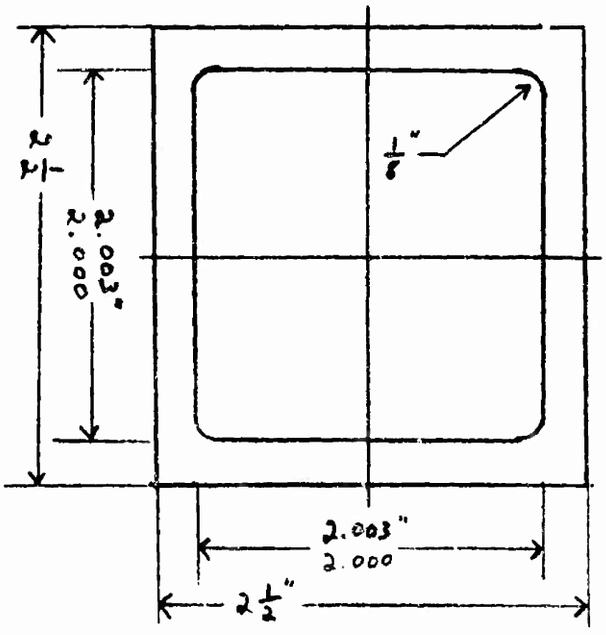


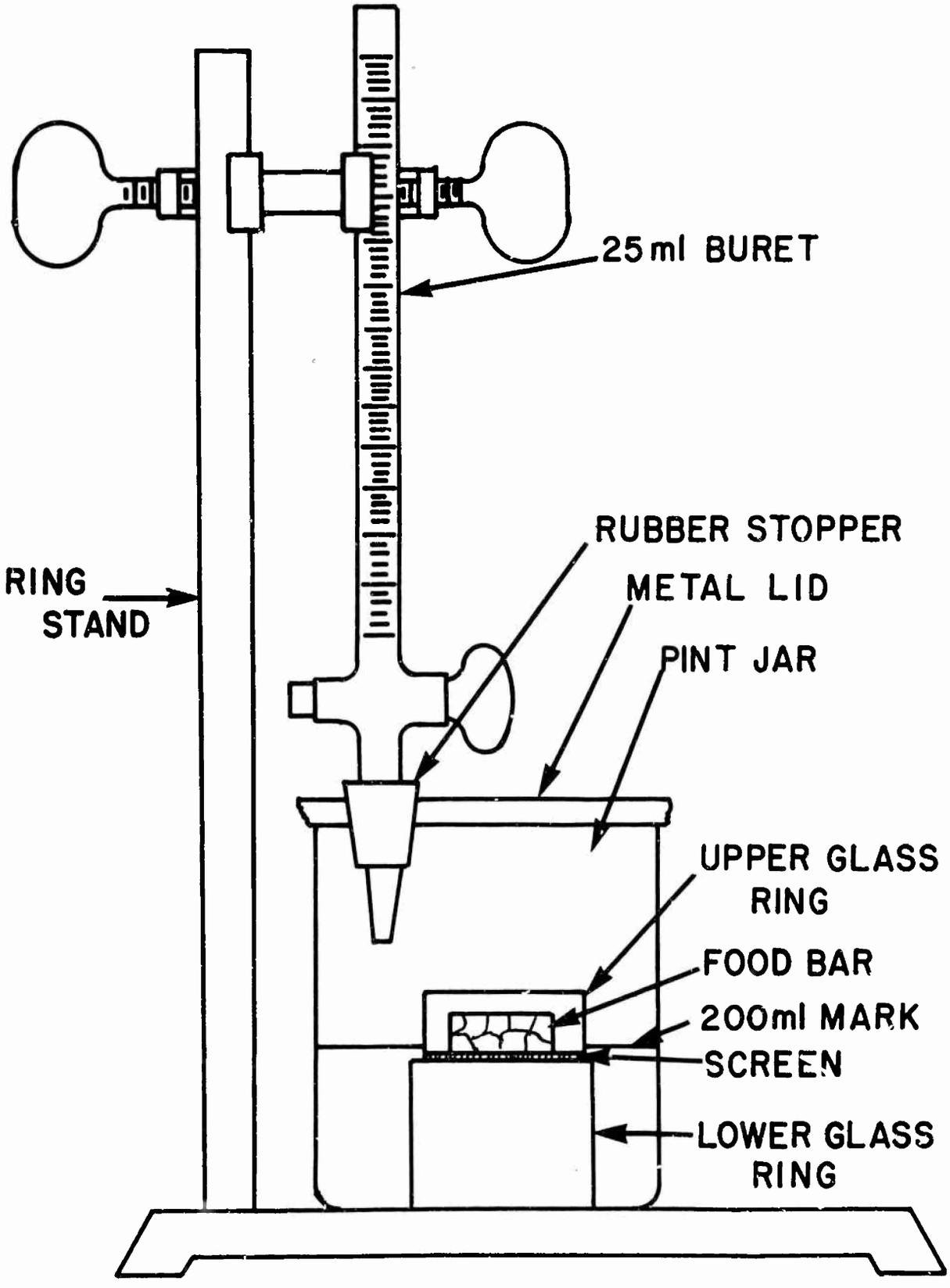
APPENDIX B

CAPILLARY REHYDRATION TEST METHOD

1. Fill the pint jar to the 200 ml mark with water @ 50°F.
2. Place the compressed bar on the screen; it should just touch the water. Put the ring around the bar.
3. Close the jar by lightly screwing down the cap.
4. Insert the burette filled with water at 50°F to the zero mark (25 ml burette)
5. Replenish with water from the burette to keep the water at a constant level (up to the 200 ml mark)
6. Read the burette at 5, 10 and 15 minute intervals.

APPENDIX B (cont)

CAPILLARY REHYDRATION EQUIPMENT



APPENDIX C

NAME _____ DATE _____ SAMPLES _____

Ballot For Evaluation of Moisture Mimetic Food Bars By Trained Profile Panel

	Not At All 1	2	3	4	5	6	7	8	9	Very Much So 10
Initial Moisture										
Hardness										
Plasticity										
Amount of Salivation										
Ease of Chewing										
Crumbliness										
Cohesiveness of Chewed Mass										
Moistness of Chewed Mass										
Dehydration of Mouth										
Ease of Swallowing										
Stuck to Teeth										
After Effect- Thirst										
Palatability										

Moisture Mimetic Foods Sensory Taste Panel Terminology For Use With Ballot

1.	Initial Moisture	Response of tongue to sensation of moistness upon first tasting.
2.	Hardness	Resistance to incisor shear during the first one or two bites.
3.	Plasticity	Sensation of brittleness or lack of brittleness.
4.	Amount of Salivation	The initial response of the saliva glands to the product.
5.	Ease of Chewing	A measure of the effort required to form a cohesive, plastic mass.
6.	Crumbliness	A measure of the relative ease of breaking the bar into small particles having little or no cohesive properties.
7.	Cohesiveness of the chewed mass	A measure of the tendency of the bar to fragment into discrete particles which require a relatively large effort to reassemble into a form which will be acceptable to the throat for swallowing.
9.	Dehydration of Mouth	A measure of the effect of the product on mouth and tongue surface after arriving at a condition of the product which permits swallowing.
10.	Ease of Swallowing	A measure of the resistance offered by the throat to the passage of the masticated food.
11.	Stuck to Teeth	A measure of the affinity of the product in terms of adhesion to the teeth.
12.	After Effect - Thirst	A measure of the residual mouthfeel or after-taste elicited as a result of swallowing the product; a cottony mouthfeel or desire for water.
13.	Palatability	An overall score of the acceptability of the product after review by the taster of the various taste and texture attributes and the scores assigned. This score is not a numerical average but rather a judgment value guided by the individual elements which together affect the taste sensations.

APPENDIX D

Data from survey of moisture mimetic agents.

APPENDIX D-1

Screening of Carbohydrates with Cornflakes as Moisture Mimetic Agents

Material	% Weight	Palatability	Initial	Ease of Mastication	Ease of Swallow	Remarks
Control: Cornflakes + Honey	11.25	6	Somewhat chewy	Hydrates moderate	Crumbly gritty pieces	Cohesive not har
Cornflakes + Glycerol	20.0	7	More chewy	More internal moisture than control	Less gritty	Cohesive
Control + Glycerol	12.4	7	More chewy	More internal moisture than control	Less gritty	Cohesive
+Anhydrous Dextrose	12.4	5	Dry and crumbly	Less moist than Control but not drying	- -	No difference anhydrous and hydrate
+Hydrate Dextrose	12.4	5	Dry and crumbly	Less moist than Control but not drying	- -	No difference anhydrous and hydrate
+Sorbitol	12.4	5	Sl.dehydrating	Sl. dehydrating & tacky	Crumbly & sl. drying	- -
+Mannitol	12.4	5	Sl.dehydrating	Sl. dehydrating & tacky	Crumbly & sl. drying	- -
+Frodex 15 DE	12.4	3	Dry and crumbly	More dehydrating than Mannitol & Sorbitol	Crumbly & sl.drying	- -
+Frodex 24 DE	12.4	3	Dry and crumbly	More dehydrating than Mannitol & Sorbitol	Crumbly & sl. drying	- -
+Fructose	12.4	4.8	Dry and crumbly	Sl. dehydrating	Crumbly & sl.drying	- -
+Lactose	12.4	5.2	Dry and crumbly	Sl.dehydrating	Crumbly & sl. drying	- -
+Molasses	12.4	6.0	Chewy, like Control	Sl.more moist than Control	Crumbly and drying	Molasses flavor very apparent
+Pure Licorice	12.4	2.7	Drier than Control	Undetermined	Undetermined	- -
+Karo	12.4	5.0	Sl. harder and more crumbly	Dry and very cohesive	Dry and very cohesive	- -
+Date Powder	12.4	4.7	Dry and crumbly	Sl.dehydrated	Crumbly and dry	- -
+Spray Malt	12.4	4.3	Dry and crumbly	Sl.dehydrated	Crumbly and dry	- -
+Brown Sugar Dk.	12.4	6.3	Somewhat moist	More moist throughout	Crumbly and dry	- -

APPENDIX D-2

Screening of Fruit Powders with Cornflakes as Moisture Mimetic Agents

Material	% Weight	Palatability	Initial	Ease of Mastication	Ease of Swallow	Remarks
Control: Cornflakes + Honey	11.25	6	Somewhat chewy	Hydrates moderate	Crumbly gritty pieces	Cohesive not hard
+Lemon Powder	5	3	Dry, crumbly	Very salvating	Burning	Firm bars
+Lemon Juice Crystals	12.4	2.5	Initially sour	Astringent	Burning	Firm bars
+Lemon Powder	12.4	3	Sour, salivating	Astringent	Burning	Firm bars
+Black Currant	12.4	4.75	Sl dryer than Control	Aided by salivation	Easier due to salivation	Firm bars
+Apricot Powder	12.4	5.25	Sl dryer than Control	Aided by salivation	Easier due to salivation	Better balance than Currant
+Tomato Powder	12.4	1.0	Drying, powdery	Sl salivating	Dry and crumbly	- -
+Banana Flakes	12.4	6.8	Initially moist	Moist with only sl salivation	Not crumbly, slides down well	Appeared dehydrated when first chewed
+Fig Puree	12.4	6.0	Similar to control →			
+Prune Powder	12.4	5.5	Sl dryer and more crumbly than Control	Sl more moist than Control	Same as Control	
+Raspberry Powder	12.4	5.3	Dry	Salivating	Not hydrated too well	- -
+Strawberry	12.4	6.2	Dry at first	Salivating and better hydration	- -	- -
+"Tang"	12.4	5.5	Similar as Control	Too salivating	Drying & astringent	- -
+"Start"	12.4	5.0	Sl drier than Control	Drying & salivating	- -	- -

APPENDIX D-3

Screening of Acids with Cornflakes as Moisture Mimetic Agents

Material	% Weight	Palatability	Initial	Ease of Mastication	Ease of Swallow	Remarks
Control: Cornflakes + Honey	11.25	6	Somewhat chewy	Hydrates moderate	Crumbly gritty pieces	Cohesive not hard
+Malic Acid	1.0	5.5	Dry	Somewhat salivating	- -	Harsher flavor
+Citric Acid	1.0	5.7	Dry	Hi sour→ salivation	Hydrates rapidly moist paste	Citric aromatic very pleasant
+Tartaric Acid	1.0	4.8	Dry	Sourness comes later	Hydrates less, more dry and crumbly	- -

APPENDIX D-4

Screening of Fats and Oils in Cornflakes as Moisture Mimetic Agents

Material	% Weight	Palatability	Initial	Ease of Mastication	Ease of Swallow	Remarks
Control: Cornflakes + Honey	11.25	6	Somewhat chewy	Hydrates moderate	Crumbly gritty pieces	Cohesive not hard
+Olive Oil	12.4	5.4	Moist	Not as crumbly	Much easier than Control	Musty flavor
+Lard	12.4	5.3	Sl. less moist	Sl. dry and crumbly	Much easier than Control	Less palatable
+Chicken Fat	12.4	6.2	Moist	Not as crumbly	Much easier than Control	Palatable
+Safflower Oil	12.4	7.3	Especially moist	Least dry and crumbly	Much easier than Control	Lt. pleasant flavor oil, less palatabl
+Wesson Oil	12.4	6.7	Especially moist	Least dry and crumbly	Much easier than Control	- -
+Coconut Oil	12.4	6.5	Especially moist	Least dry and crumbly	Much easier than Control	- -
+Drew Kreme	12.4	7.0	Moister than Control	Hydrates well, not crumbly	Easy to swallow	Pleasant taste
+Palm Oil	12.4	3.0	Moister than Control			Objectionable flavo and aroma
+Wecobee	12.4	6.5	More moist than Control all stages			
+Wecotop "A"	12.4	6.1	Sl. drier than Wecobee	Sl. crunchy and dehydrating	Harder to swallow	More acceptable than Control

APPENDIX D 5

Screening of Proteins with Cornflakes as Moisture Mimetic Agents

Material	% Weight	Palatability	Initial	Ease of Mastication	Ease of Swallow	Remarks
Control: Cornflakes + Honey	11.25	6	Somewhat chewy	Hydrates moderate	Crumbly gritty pieces	Cohesive not hard
+Egg White	12.4	4.5	Drier than Control	Dehydrating and Sticky	Difficult	- -
+Sodium Caseinate	12.4	4.2	Dehydrating	Especially gluey and pasty	Difficult	- -
+Promine D	12.4	4.0	Dehydrating	Especially gluey and pasty	Difficult	- -

APPENDIX D 6

Screening of Emulsifiers in Oil as Moisture Mimetic Agents

Material	% Weight	Palatability	Initial	Ease of Mastication	Ease of Swallow	Remarks
Control: Cornflakes + Honey	11.25	6	Somewhat chewy	Hydrates moderate	Crumbly gritty pieces	Cohesive not hard
+Safflower Oil and Emulsifier	1.0	5.8	Soft and crumbly	Sl. dehydrating	Leaves greasy mouth film	Not firm bar
+Propylene Glycol Monostearate	3.5	5.3	Crumbly	More dehydrating than 1.0%	Greasy	- -
+Glycol Monostearate	1.0	5.6	Initially moist	Sl. dehydrating and greasy	Sl. coating	
	3.5	5.4	← Similar to above →			
+Lecithin	1.0	4.5	Sl. dry and crumbly	- -	Gluey and hard to swallow	Off flavor
	3.5	4.0	Sl. dry and crumbly	- -		

APPENDIX D-7

SCREENING OF VARIOUS MATERIALS WITH CORNFLAKES AS MOISTURE MIMETIC AGENTS

Material	% Wt.	0-10 Palatibility Rating	Initial	Ease of Mastication	Ease of Swallow	Remarks
Control						
Cornflakes and Honey		6.0	Somewhat low moisture - crumbly	Hydrates slightly less than moderate	Slightly less than moderate	Little or no unpleasant after taste or thirst effect
Waxes						
Carbo-wax	2.5	5.3	More moist than control - crumbly	Easier than control	Same as control	Better overall bar than control - slight off flavor
Stearic Acid	10.0	2.0	Somewhat less moist than "A"	Similar to control	Same as control	Bitter and soapy flavor
Sweetner						
Sodium Cyclamate	0.25	1.5	Somewhat moist	Poor - less than control	Somewhat better than control	Overly sweet, gritty texture - more cohesive than control
Flavor Enhancers						
Monosodium glutamate	0.01	2.0	Crumbly, moisture less than control	Poor - less than control	Less than control	- - - - - - - -
Ribotide	0.01	1.8	Dry and crumbly	Poor - less than control;dehydrating	Less than control	Highly flavored - very dehydrating
"Mertaste"	0.01	1.5	Same as control	Slightly higher than control;dehydrating	Somewhat better than control	"
Coolants						
Ice Cream Coolant	0.01	4.0	Less than control crumbly, dry	Poor - less than control;dehydrating	Very poor	Very dehydrating; difficult to swallow
Menthol	0.125	1.0	Very dry	Less than control, dehydrating	Very poor	Showed least amount of crumbliness;high in menthol
Bitter						
Narringen	0.01	1.0	Crumbly, dry	Less than control	Very poor, dehydrating	High level of bitterness obscured positive characteristics in all samples
Caffeine	0.01	1.0	" "	" " "	"	
Chiretta	0.125	1.0	" "	Similar to control	"	

APPENDIX D-7 (cont)

Material	% Wt.	0-10 Palatibility Rating	Initial	Ease of Mastication	Ease of Swallow	Remarks
Astringent						
Quabracho Extract	0.01	2.5	Similar to control	Similar to control	Less than control, dehydrating, burning	Dry mouthfeel, unpleasant aftertaste
Spice						
Cassia	0.125	3.5	Similar to control	Drying & salivating excessive salivation led to sensations of dehydration and astringency	Difficult to swallow, stuck to teeth	Similar to control in hardness and plasticity

APPENDIX E

Benchtop Procedure For Whipped Emulsion

1. In a stainless steel container melt together Wecotop, Propylene Glycol Monostearate, Lecithin and Wesson Oil. Heat to 50°C.

2. To a Waring Blendor add the proper amount of spring water at 20°C; preblend sugar and sodium caseinate and add to water in blendor. Whip at high speed for 2 minutes; insure good solution of material.

3. Add to the caseinate/sugar/water blend, the mixture of hot fats (cf. step #1).

4. Blend at high speed for ten minutes in the Waring Blendor.

5. Rapidly cool in ice bath to 15°C; sample for over-run.

6. Return over-run sample to batch and whip at Speed #5 in the small bowl of the mixmaster for 30 seconds. Increase speed to Speed #11 (825-875 rpm.), continue to beat for 4-½ minutes. Use rubber spatula to guide whipped material into beaters. Sample for over-run and viscosity.

APPENDIX F

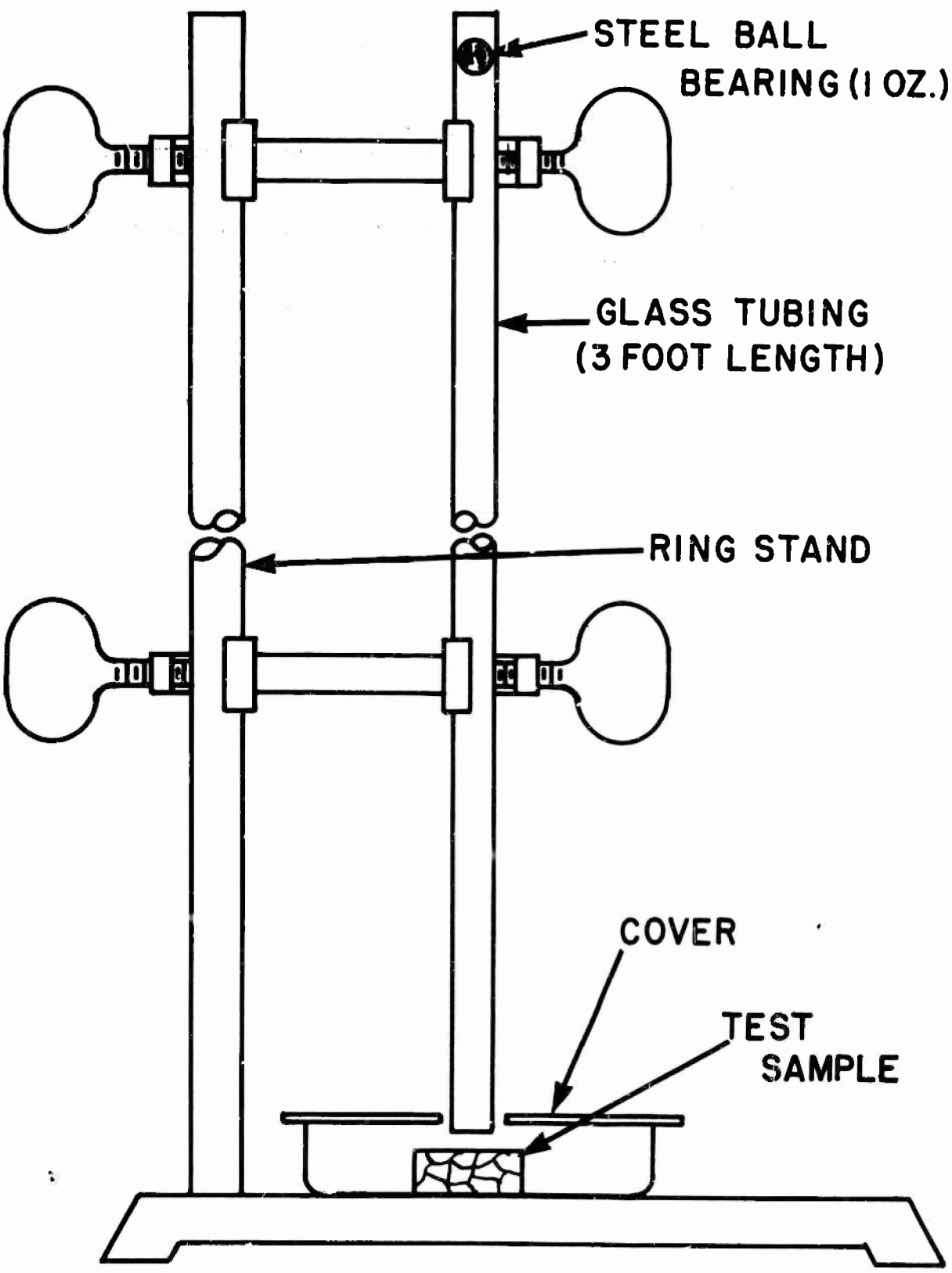
SHATTER TEST METHOD

1. Place compressed bar sample in centering device (unwrapped sample is then automatically centered directly beneath the glass tube).

2. Allow the steel ball to fall through the tube and strike the test sample.

3. Record the number of falls necessary to fracture the test sample.

APPENDIX F (cont)



APPENDIX G

STATIC REHYDRATION TEST METHOD

HOT TEST

1. Submerge compressed bar in 100 ml of distilled water at 160°F.

2. Record the degree of "sluffing" or shedding of the components away from the bar matrix as time elapses during the test period. (5, 10, 15 minute intervals)

COLD TEST

1. Submerge compressed bar in 100 ml. of distilled water at 50°F.

2. Record the degree of "sluffing" or shedding of the components away from the bar matrix as time elapses during the test period. (5, 10, 15 minute intervals)

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13. ABSTRACT

Moisture mimetic agents and panel techniques have been identified and a bench-top procedure applied to dehydrated compressed food bars to eliminate or reduce the sensation of dryness. Preliminary studies have produced chicken stew, chicken, peas and cereal bars which have the prerequisite cube form, nutrition and reduced dryness when consumed. Sensory taste panel data have shown that the classes: polyhydric alcohols, sugars, fruits, fats and oils exhibit beneficial moisture mimetic properties as additives to compressed dehydrated foods. Rehydration, storage and structural stability tests are reported.

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14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Simulation	8		4			
Moisture	9		4			
Mouth	9		4			
Moisture mimetic agents	10		1		6	
Food bars	5		1,2		9	
Dehydrated foods	5		1		9	
Freeze dried foods	5		1		9	
Military rations	4				9	
Applying			8			
Storage stability					7	
Rehydration					7	