FURTHER STUDIES ON THE DEVELOPMENT OF A NUTRITIONALLY ADEQUATE FALLOUT SHELTER RATION

FINAL REPORT (Part I of II)
March 1966

MRI Project No. 2769-B

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Prepared for

Office of Civil Defense
Department of the Army, OSA
Contract No. OCD-PS-64-120
Work Unit 1315A

MRI
MIDWEST RESEARCH INSTITUTE
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by

H. E. Newlin
G. L. Hayes

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PREFACE

Midwest Research Institute Project No. 2769-B, "Further Studies on the Development of a Nutritionally Adequate Fallout Shelter Ration," was performed under Contract No. OCD-PS-64-120 for Civil Defense Technical Office during the period 26 March 1964 to 29 October 1965. The research was conducted by Dr. H. E. Newlin, Project Leader, with the assistance of Mr. G. L. Hayes, in the Food Technology and Nutrition Section. This section is headed by Mr. O. B. Gerrish and is, in turn, a part of the Biological Sciences Division, of which Dr. W. B. House is Director.

Approved for:

MIDWEST RESEARCH INSTITUTE

W. B. House

W. B. House, Director
Biological Sciences Division

22 March 1966

ABSTRACT

Midwest Research Institute has developed nutritional supplements for consumption with presently available shelter rations. When consumed as directed, these supplements will supply all the nutritional factors recognized by the National Research Council as essential for the maintenance of adults. They will extend the use of shelter rations to shelter occupants who require special feeding, and to the general population, during the post-attack period. The supplements are of two types: unflavored compressed tablets; and dehydrated spreads, flavored so that they will enhance the palatability of ration biscuit, cracker, and wafer. Accelerated storage tests indicate that (a) the tablets have a high expected shelf life, and (b) the flavor of the spreads should be further stabilized.

New mint-type and tableted granular starch carbohydrate supplements have been developed, which are soft-textured and fully compatible with the mucous membranes of the oral cavity.

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SUMMARY

Supplements have been developed to widen nutritional choices and to enhance the acceptance of present stocks of fallout shelter ration biscuit, cracker and wafer. When used as directed, the nutritional supplements -- (a) and (b) -- will provide all recognized adult maintenance requirements for protein, amino acids, vitamins, and minerals.

The concept of nutritional enrichment is designed to make the rations a more nearly complete diet for extended periods of maintenance, and to provide a supply of extra nutrients for individuals with special nutritional demands. Nutritional supplements have been designed to supply 25 per cent of the total calories of a 1,500 cal/day diet, and shelter rations will make up the remaining 75 per cent. Composition of the supplements was based on average analysis of a mixture of equal parts of survival ration biscuit, cracker and wafer. These supplements, in combination with the rations, are required to meet an adult's maintenance requirements for all nutritional factors for which the National Research Council has defined a need, i.e., protein, essential amino acids, and the essential vitamins and minerals.

These supplements are of three types: (a) nutritional tablets, (b) nutritional, palatability-enhancing spreads, and (c) readily-consumed, soft-textured carbohydrate supplements.

Nutritional Tablets

The supplements developed primarily for furnishing nutritional adequacy are in the form of an austere tablet, which is intended to be packaged in the same manner as the rations, to resemble them in flavor and texture, and to be eaten either with the rations or separately. Two formulas, designated as A6-4 and A7-2, based on casein and soybean grits, are suggested as shelter items: A6-4, containing defatted peanut meal; and A7-2, made with a high protein bean bread. Both formulas are made by absorbing fat in a granular base, moistening, adding powdered ingredients as binder, compressing in a 1-1/4 x 1-1/4 in. die, and drying to less than 5 per cent moisture.

Formulas A6-4 and A7-2 had good acceptability and a high degree of stability. Taste test panel ratings for flavor and texture were only slightly decreased by four months' storage in sealed containers at 100°F. The tablets became slightly toasted after storage at 120°F for this period, but not stale or rancid. Loss in thiamine and increase in peroxides were negligible at either temperature. A slight but not organoleptically perceptible increase in free fatty acids occurred.

Nutritional and Palatability Enhancing Spreads

Spreads, which will be applied on the rations, have been designed for nutritional enrichment, and, at the same time, enhancement of palatability. Ready-to-eat spreads were abandoned, because satisfactory spreading consistency could not be developed in a composition which possessed all the required nutritional values. However, these dual objectives were approached with spreads of fat-filled soybean grits, having corn syrup as a spreading medium.

Eight satisfactory nutritional-palatability spreads were developed, in the form of dehydrated mixtures; these can be reconstituted by stirring with an equal quantity of water. The flavor of these spreads was based on a survey of the flavor compatibility of a wide variety of prototype spreads with the rations.

The eight dehydrated spreads were flavored with chicken, cheese, chili and ham. The dehydrated mixes reconstituted readily, to give spreads with satisfactory consistency and appealing flavors, which improved acceptability of ration crackers. However, preliminary stability tests indicated that special precautions will be needed to prevent flavor loss and off flavor development during long-term storage.

Austere tablets are a more promising ration supplement item than flavor enhancing spreads. The tablets will probably be less expensive than the spreads, and can be more easily handled by shelter occupants. The stability of tablets is greater than that of spreads, and the flavor more widely acceptable.

Soft-Textured Carbohydrate Supplements

Two satisfactory forms of revised carbohydrate supplement, which are easily chewed and do not cut the mouth, were developed. Mint-type supplements were made from precipitated sugar, and starch agglomerates from tableted granules of precooked cornstarch and precooked potato, tapioca, and rice. The former were suitably flavored with peppermint, and the latter with molasses. Both forms appear to have high storage stability.

I. INTRODUCTION

Emergency food supplies are an important part of this country's civilian defense effort. Fallout shelters are currently stocked with rations consisting chiefly of specially developed survival biscuits, crackers, and wafers. These three baked items largely fulfill the immediate requirements for a food supply for short-term shelter feeding. They are highly stable and low in cost. Their composition is based on the best nutritional and physiological information applicable to shelter occupancy available at the time they were formulated.

Present research in shelter feeding, however, is directed toward more than the objective of simply providing something to eat to the average victim. Greater nutritional adequacy, with greater acceptability and variety, are objectives for future rations, and have become so for two important reasons:

1. They should be able to cover the needs of individuals requiring special nutrition, e.g., the aged, the young, pregnant and lactating females, burn and hemorrhage victims, and individuals with chronic metabolic diseases (diabetes and nephritis, for example).

2. Shelter stores might be used in the post attack period, in which case they would have to be consumed for an extended length of time.

The biscuit, cracker, and wafer were formulated on the basis of low water intake and urinary excretion in the shelter occupants. For this reason they are largely a carbohydrate and energy source, and do not contain several important nutritional constituents. If these rations are to be nutritionally adequate, and are to serve as the sole diet for more than a few days, they must contain larger amounts of more complete protein, as well as adequate supplies of the vitamins and minerals for which man has a recognized need.

Two approaches are possible to achieve the goal of better shelter feeding: existing shelter rations can be supplemented, or the shelters can be restocked with more adequate food items. The original plan of the present project called for work on both approaches. "Plan A" consisted of developing a supplement and "Plan B" called for improved ration formulations.

A further objective in the original project plan called for evaluation of the effects of supplementation and reformulation of the rations on their

biological efficiency. Energy, protein, and water utilization of present and improved rations was to be compared through the use of rats. Also, the consistency of a carbohydrate supplement, which is currently stocked with ration biscuit, cracker and wafer had to be improved. This carbohydrate item is a hard candy, which is fed to reduce the level of dietary protein. Because the present form breaks into sharp pieces which can cut the mouth, a softer form of carbohydrate supplement had to be developed.

For the first six months of the contract period we proceeded according to the original research plan. The design and formulation of a supplement tablet suitable for feeding with the rations were completed, and storage-stability tests on this item were initiated. Feeding studies were outlined; revised carbohydrate supplements were developed. However, in September, 1964, the Project Coordinator advised us that palatability had become a serious problem in the rations. Feeding studies with humans indicated that rations, if used as the sole diet, frequently became unacceptable in less than two weeks. Accordingly, we were asked to develop a supplement which enhanced the palatability of the biscuit, cracker and wafer, as well as their nutritional value.

Spreads, to be applied to the rations, appeared the best means of attaining the new, dual objective, and the latter part of the research period was devoted to the development of spreads. A study of forms, flavors, and ingredients led to the formulation of a series of dehydrated spreads, which met specifications for both palatability and nutritional analysis. The initial project objectives (reformulation of the rations, and the biological evaluation of supplemented rations) were abandoned by mutual agreement in favor of the more urgent problem of developing palatable spreads.

This final report deals almost entirely with formulation studies. For both supplement tablets and spreads, the research approach consisted essentially of the following steps:

1. Development of nutritional and physical specifications.

2. Collection of suitable ingredients.

3. Development of a physical form.

4. Modification for nutritional value and acceptability.

5. Chemical and cost analysis.

6. Preliminary tests for storage stability.

With less elaboration, these same steps were also applied to revised carbohydrate supplements.

The development of supplements is described in Section II of the report. Subsection A-1 describes the nutritional basis on which both tablets and spreads were formulated. Subsection A-2 deals with tablets; A-3, with spreads. Subsection B describes revised carbohydrate supplements, and Subsection C, the planning which was done on biological evaluation.

Section III presents a discussion of the relative merits of the products developed, and of several problems still to be overcome in the feeding of fallout shelter occupants.

Future research studies on shelter supplements are outlined in Section IV.

II. EXPERIMENTAL

A. Nutritional and Palatability Supplements for Use with Present Shelter Ration, Biscuit, Cracker and Wafer

1. Nutritional specifications for the supplements: The first objective of the project was to develop a sound basis for the nutritional fortification of the shelter rations. A clear concept was needed of which factors in these rations should be enriched, and to what extent it would be practical to enrich them.

The background for current formulations of ration biscuit, cracker, and wafer was reviewed at the start of the project. Literature references indicated that specifications for these items are based on numerous surveys by authorities on emergency feeding, and on extensive research performed in this field.

The recommendations of four authorities on the composition and feeding of shelter rations are summarized in Table I.* These recommendations have been designed for rations to be fed in limited quantities, and with a highly restricted water intake. For such rations, protein is restricted to about 8 per cent of the total calories (to limit urinary water excretion); and sodium chloride is also adjusted to conserve body fluids. Carbohydrate

* Tables I through XX are shown in Part II.

makes up the majority of the calories, and fat is included for caloric density and its physiclogical effect. The recommendations do not emphasize vitamin and mineral content, or biological value.

Military specifications for ration biscuit, cracker and wafer[1,2,3] follow closely the above recommendations and they are intended to provide a diet which is suitable for immediate shelter use. However, the deficiencies in this diet for longer term feeding, or for special nutritional cases, are obvious, and demonstrate the points at which enrichment should be made.

We needed accurate analytical data on the rations as a basis for fortification. As shown in Table II, the literature provided several representative values for proximate analysis. However, available figures for vitamins and minerals were fragmentary, and conservative estimates of these figures were made, based on the ingredient composition of the rations (see Table III). A table of amino acid values was compiled, based chiefly on the figures reported by Longenecker[4] and Wilcox[5] (Table IV).

The figures in Tables II, III, and IV served as a baseline for enrichment. Recommendations such as those in Table I indicated that a food level of 1,500 Cal/day per person is satisfactory for shelter feeding, and we planned that supplements would make up 25 per cent of this total food intake.

The National Research Council has clearly defined the nutritional factors needed by humans,[6] and we have used the NRC dietary recommendations. The unsupplemented rations at a 1,500 calorie level are deficient in several of the required nutritional factors. If the planned amount of supplement were used, it would have been possible to fortify with vitamins and minerals even to the high levels specified by NRC for growth and reproduction. However, sufficient protein could not be included in the supplement to cover the higher requirements for protein. Accordingly, we decided to enrich all factors specified by NRC only to the levels necessary for the maintenance of grown males. We also decided that all essential amino acid requirements[7] for such an individual should be met, and that, in addition, the mixture of ration and supplement proteins should have as nearly an ideal biological value as possible.

Presumably persons requiring fortified diets would not eat the carbohydrate supplement. Fortification was therefore calculated only on the basis of rations plus nutritional supplement.

NRC recommended dietary allowances indicate that grown men of average activity should receive 70 g. of protein per day. As an optimum goal, we therefore specified that supplemented rations should contain 70 g. of protein/1,500 calories. Because activity in shelters is necessarily restricted, the minimum objective was defined as 60 g. of protein, which meets most of the normal requirements of women and children.

For maximum usefulness, a single supplement should be as effective as possible, whether it is used with ration biscuit, cracker, or wafer as the main portion of the diet. For this reason, the calculation of a supplement's composition was based on an average analysis of all three items -- biscuit, cracker, and wafer, rather than the analysis of any single one of these items.

The supplement should have approximately the same calorie content as the rations. If it has fewer calories, excessive amounts of supplement will have to be stocked and consumed; if it has more calories, nutritional factors per given weight of supplement become over-concentrated.

The calculated average energy value of the biscuit, cracker and wafer was 4.13 cal/g. Therefore about 364 g. of a 1:1:1 mixture of these items will be consumed daily at a 1,500 calorie level. The supplemented mixture will consist of 273 g. of rations and 91 g. of an equicaloric supplement. The average protein content of rations was 8.52 per cent, and they will provide 23.2 g. of protein in a supplemented ration. Ninety-one grams of supplement must therefore contain 36.7 g. of protein, or have a protein content of at least 40.39 per cent, in order that the supplemented diet can provide 60 g. of protein per day.

The nutritional factors to be enriched, and the daily nutrition provided by unsupplemented and supplement mixtures of rations are summarized in Table V. In Table VI, analysis of a 1:1:1 mixture of ration biscuit, cracker and wafer is compared with the required analysis of the supplement.

The composition of protein mixtures in supplements was calculated so as to provide optimum biological value in a mixture with rations and supplement. Three systems of scoring, which enable one to calculate how well deficiencies in essential amino acids have been overcome, were used. These systems are outlined in Appendix A-1.

The above proximate, vitamin, mineral and amino acid specifications provided a nutritional basis for supplement tablets (see the next section). The same specifications were used, on a 5 per cent moisture basis, for dehydrated supplement spreads (Section 3).

2. Nutritional supplement tablets:

a. Developmental stage: After preliminary trials with a number of other forms, two tableted nutritional supplements were developed which met all the nutritional specifications listed in the previous section.

The development of tablets was based on an elaboration of the form and composition of a number of protein mixtures. Such mixtures were progressively modified for biological value, cost, consistency and flavor. Additives were gradually introduced until complete supplement formulations were obtained.

A list of the protein mixtures investigated appears in Table VII. Protein Mixtures 1 and 2 were formulated to demonstrate mixtures with a high biological value, but containing limited amounts of animal protein. Several forms, including a preliminary ready-to-eat spread, were made from Protein Mixture 3.

Protein Mixtures 4 - 9 were based on casein as animal protein; less expensive protein concentrates derived from soybean, wheat, and peanuts were added to them. After attempting to prepare ready-to-eat spreads from Protein Mixture 8, and to form this protein mixture by wetting it, we concluded that tablets offered the best opportunity of fulfilling all nutritional specifications.

Protein Mixture 8 could not be tableted satisfactorily when a potato-flake filler, a sorbitol binder, and other medium-fine-ground ingredients were used. However, promising tablets were made from this mixture when the casein and Promine* which it contained were flaked and coarse ground in the laboratory, and bread or precooked rice, both coarsely ground, were used as fillers. Our general procedure -- moistening the mixture of coarse ground materials, tempering, and adding a powdered binder prior to tableting -- proved satisfactory.

The biological value of Protein Mixtures 4 - 9 was estimated, using the calculations described in the preceding section. Protein Mixtures 6 and 7 were found to have the best ratings, and when fortified with small amounts of methionine, fulfilled all amino acid requirements. Fortified Protein Mixtures 6 and 7 were therefore selected for development into complete tableted formulations.

b. Completed formulations: Complete nutritional supplements were prepared from Protein Mixtures 6 and 7 by the addition of suitable carbohydrate, fat, vitamins and minerals, and by tableting under a satisfactory set of conditions.

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* Isolated soybean protein, Central Soya Company, Inc., Chicago, Illinois.

A vitamin-mineral mix for use at a uniform level in the tablets was formulated. Highly bland vitamins with a long-expected stability were found to be the coated, bead-type prepared by Hoffmann-LaRoche, Inc., Nutley, New Jersey. Flavor and stability considerations also led to calcium carbonate as the form for calcium, and sodium iron pyrophosphate as the form for iron. Equicaloric composition in the tablets required 8.5 g. fat per 100 g. of ingredients. A stabilized, 100-hr. AOM* fat was selected.

Supplement A6 was prepared from Protein Mixture 6, using three different carbohydrate fillers: precooked rice, mashed potato flakes, and a stable high-protein bread made with beans. Casein of 30 mesh size was employed, and the soy grits, peanut meal, and carbohydrate fillers were ground to suitable particle sizes, falling chiefly within the No. 12-30 U.S. Standard screen size range. Granular bases were warmed with the melted fat to allow absorption of this material. After the fat had been added, the bases were moistened and tempered. Fine ground binders,consisting of vitamin-mineral mix, salt, and sorbitol, were then added, and the completed mixes were tableted in a 1-1/4 x 1-1/4 in. die under moderate pressure. Finished tablets were dried to a moisture content of less than 5 per cent.

The potato-flake and bean-bread versions of supplement A6 had the best flavor and structure. Development of A6 in the potato formula was continued, and Protein Mixture 7 was prepared satisfactorily as supplement A7, using bean bread as carbohydrate.

Minor adjustements were made in formulas A6 and A7 to conform with nutritional specifications. Salt was removed from the formula because the salt level was considered too high for shelter use. The adjusted formulas A6-4 and A7-2 were regarded as satisfactory for analysis and stability testing. The complete tablet formulas are presented in Table VIII. The formula for the vitamin-mineral mix used in these tablets is shown in Table IX, and the procedure for preparing the tablets is detailed in Appendix A-2.

Tablet size and projected packaging for tableted supplements were based on consumption of 91 g/day as 25 per cent of a 1,500 calorie diet (see Section II-A-1 above). Because supplement consumption was estimated at the rate of 10 tablets/day, the average tablet weight was adjusted to 9.1 g. The packaging suggested for tablets is heat sealable glassine, with five tablets wrapped in a package. Such packages measure approximately 1-5/16 x 2-3/8 in.,and multiple package units can be made up in sealed metal cans, in the same manner as ration biscuit, cracker, and wafer.

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* Accelerated Oxygen Method.

c. Stability, analysis and acceptability of completed formulations: Significant data were obtained on the stability, analysis and acceptability of tableted nutritional supplements A6-4 and A7-2.

In a preliminary accelerated storage test, prototypes of the completed tablet formulas did not develop rancid odors after two weeks at 130°F. Also, review of the data assembled by Woodroof[8] indicated good stability for the principal ingredients of the completed formulas. These two pieces of information appeared to justify a more extensive accelerated storage test on A6-4 and A7-2.

A four-month accelerated storage test was conducted on the two tableted formulas. A quantity of each formula was freshly prepared from a uniform batch of ingredients. These tablets were analyzed for proximate values, and for calcium, iron, Vitamin A, thiamine, riboflavin, niacin and Vitamin C. The remainder were then wrapped, five to a package, in heat-sealed glassine, and the packages, occupying a space approximately half of that occupied by the tablets, were sealed in metal cans.

A series of reference cans was stored at 0°F, and cans for accelerated storage were held at 100°F and 120°F. At the end of (a) two-, and (b) four-months storage, samples were analyzed for thiamine, fat, free fatty acids, acid value, and peroxide value. A panel of five experienced tasters rated the 0°F controls against the 100°F and 120°F samples for odor, flavor and texture, using the 10-point hedonic scale of Dawson and Harris.[9] The colors of the samples were compared visually. The taste testing procedure is outlined in detail in Appendix A-3.

Results of the storage test, as presented in Table X, indicated a high degree of stability for both formulas. There was no significant loss of thiamine, decrease in extractable fat, or increase in peroxide number. Free fatty acids and titrable acidity increased slightly, but not enough to cause off flavors. Color was unchanged following storage at 100°F, but slight yellowing took place at 120°F. Flavor and odor of both formulas became cereal-like at 100°F, and toasted at 120°F, but staleness and rancidity were not evident, and texture remained essentially unchanged.

Acceptability of the two fresh tablet formulas can be judged by the ratings on the 0°F samples. Scores for odor correspond to "good"; for flavor, to "average" and "slightly good"; and for texture, to "slightly good."

The results of a complete analysis of the fresh tablets appear in Table XI. These figures indicate a very close agreement with the calculated values, and therefore the tablets satisfy the nutritional specifications for all factors analyzed (see Table VI).

A sample of the shelter rations was analyzed at the same time as the above fresh tablets, and the data from this analysis also appear in Table XI. The ration sample consisted of a mixture of equal parts of shipments of biscuit, cracker, and wafer, received here in May 1964. The values reported agree very well with those obtained from the literature (see Table II).

As accurate an estimate as possible of ingredient costs of the tablets was made, based on maximum-quantity, bulk-price quotations obtained in May 1965. On this basis, A6-4 cost 29.16 ¢/lb and A7-2 cost 24.02 ¢/lb. These prices are considered moderate for dry, high-protein, vitamin- and mineral-enriched food items.

2. Nutritional and palatability supplement spreads: The development of ready-to-eat nutritional and palatability supplement spreads was investigated, but dehydrated spread mixes proved more feasible. Flavors for dehydrated spreads were studied, and suitable dehydrated spreads were developed.

a. Ready-to-eat spreads: During the course of the project, a second objective for the supplements was introduced: the supplements were to enhance the palatability of the shelter ration, biscuit, cracker, and wafer, as well as their nutritional value. Spreads, applied to the rations, appeared a good possibility for making the rations more acceptable and less monotonous. Spreads with suitable physical form and flavor and, at the same time, nutritional values equivalent to those in the tableted supplements, were therefore investigated.

Ready-to-eat spreads received initial attention, as these spreads appeared simpler for shelter use than any requiring special preparation by the occupants. The basis investigated for ready-to-eat spreads was a semi-fluid spreading medium, or binder, in which the essential nutrients were suspended.

Hydrogenated fat showed promise as a spreading medium for a fine ground protein mixture (Protein Mixture 3, Table VII). However, 40 per cent fat was required for satisfactory spreading consistency, and this amount greatly exceeded the caloric specification for the supplement. A similar high level of hydrogenated fat was required for Protein Mixture 8 (Table VII), and the level was not markedly reduced when liquid fat was used.

A second possible spreading medium, corn syrup, was investigated for fine ground proteins, but the amount needed for satisfactory consistency was at least 50 per cent, both with the above two protein mixtures, and also with the soluble proteins, sodium caseinate and isolated soybean protein.

A granular form of protein was next investigated, to learn if less binding medium could be used than with fine protein. Extracted soybean grits, ranging from No. 18 to No. 50 U.S. Standard screen sizes, were not excessively granular for spreading when mixed with hydrogenated fat, and they required less fat for this purpose than grits slightly finer than No. 50. A minimum fat content required for spreads, 25 per cent, was obtained with grits of 30 - 50 screen size.

The amount of corn syrup required for good consistency spreads made from 30 - 50 screen size soy grits was only slightly less than with the fine ground material. However, decidedly less corn syrup was needed when the soy grits had been soaked in melted fat. Quantitative investigation showed that the total amount of binder required was minimized in a spread consisting of 10 parts of 30 - 50 size grits, soaked in 2 parts hydrogenated fat, and bound with 10 parts corn syrup, prepared according to the procedure described in Appendix A-3. This composition, which contained about 45.6 per cent soy grits, 23.6 per cent protein and 9.1 per cent fat, was the ready-to-eat spread which most closely approached the nutritional requirements. It had a pleasant, nut-like taste, and spread reasonably well over a ration cracker, although it was slightly stiff and granular. Attempts to refine this spread and improve its nutritional value met with only limited success. These attempts, and the results, are summarized in Table XII.

Fat filling of a number of other 30 - 50 screen size food particles did not improve the consistency of their corn syrup spreads as much as it had with soy grits. As an example, when Protein Mixture 10 (Table VII) was soaked in fat and mixed with corn syrup in the same manner as the soy grits, a granular composition rather than a spread was obtained. Experiments with other 30 - 50 food particles suggested that the porosity, density and possibly the shape are critical, if a benefit is to be obtained from filling with fat.

The technique of fat-filling granular particles was the only promising one developed for approaching the required nutritional values in spreads based on fat or carbohydrate syrup. However, it appeared that the fat-filled granular spreads, and ready-to-eat spreads in general, were highly restricted in their ingredients. Adjustment of the formula for nutritional quality and flavor would require more research effort than was justified in the project. Further development of ready-to-eat spreads was therefore abandoned, in favor of work on dehydrated spread mixes.

b. Flavor compatibility of spreads with that of the shelter rations: Dehydrated spread mixes, to be mixed with water in the shelters, were next investigated. We soon learned that such mixes, because of their water base, release flavor in the mouth much more rapidly than fat- or syrup-based spreads; for these, flavor is therefore considerably more important than in ready-to-eat compositions.

The flavor of soy flour, soy protein, caseinate and wheat germ mixtures, made up in water, was acceptable but not appealing. Water-based spreads made from the balanced Protein Mixtures 6 and 7, used in the tablets (Table VII), had a mild, but not objectionable cereal taste. However, a satisfactory salty meat flavor could not be built up in Protein Mixture 7 spreads by means of any of a number of different additives. The flavors of these spreads were unpleasant, and they were incompatible with that of the ration cracker. The preliminary experiments indicated that basic information as to which spread flavors will supplement those of the rations was needed.

A survey was made of the flavor effect of a number of different dehydrated spreads on that of the shelter rations. Dehydrated spreads for this screening experiment were made from bland nutritional bases, flavored with dehydrated commercial foods or flavoring ingredients, including such items as dehydrated meats, soups, vegetables, and desserts.

Composition of the three bases used for flavor screening is shown in Table XIII. Each of these contributed a minimum amount of flavor, made up to a satisfactory consistency with an equal quantity of added water, and had an analysis roughly resembling that of the nutritional supplement tablets. For the flavor-screening test, the flavor additives were fine ground, and mixed with the bases at suitable levels, ranging from 3 - 33 per cent. The flavored spreads were mixed with approximately equal quantities of distilled water, held for 15 minutes, and then tasted; liberally applied to ration cracker; and in a number of cases, applied also to biscuit and wafer.

The flavors of the spreads were rated by three experienced tasters, on the basis of whether they improved, had little effect on, or detracted from the flavor of the rations. The results of the survey are summarized in Table XIV. They indicated that flavors such as ham, cheese, chicken, and several sweet flavors could enhance the palatability of the cracker, while other flavors, including smoke, fruit and chocolate, were incompatible and made the cracker less acceptable. The survey was later made more comprehensive by including several ready-to-eat commercial spreads.

Many spreads improved acceptability of all three rations. However, several had a flavor-enhancing effect on one ration and not on the others. For example, dehydrated chicken flavor, made up with spread base No. 57 (Table XIII), improved the acceptability of the cracker, had negligible effect on the wafer, and was incompatible on the biscuit. This specific compatibility was further demonstrated by comparing the taste of several commercial ready-to-eat spreads on biscuit, cracker, and wafer, and the ratings of three tasters are shown in Table XV. Three of the six spreads tasted had specific flavor compatibility. The importance of specifically designating the rations on which any spreads are to be used was therefore shown.

c. Development of dehydrated spreads: Dehydrated spreads were developed, having several of the most promising flavors indicated in the flavor survey. The requirements for these spreads were as follows:

1. The dehydrated spread, containing less than 5 per cent moisture, should fulfill the nutritional specifications for supplements, as defined in Section II-A-1 above.

2. The dehydrated spread should reconstitute rapidly under simple hand-stirring with water, to give a moist spread suitable for immediate use.

3. Reconstitution should be possible with a moderate quantity of water, preferably one part water to one part dehydrated spread.

4. The moistened spread should have a smooth, easily applied consistency.

5. The flavor and consistency of the moistened spread must improve acceptability of at least one of the three rations.

6. Raw materials costs should be as low as possible.

Prototype dehydrated spreads for use with cracker were developed, made from spread base No. 57 (Table XIII) and suitable flavors. These spreads were then refined until they entirely fulfilled the above specifications.

The refinement was based on the availability of a suitable set of protein concentrates. All available protein concentrates were reviewed for cost, reliability of supply, analysis and biological value. The east with which they reconstituted, and the physical properties of their aqueous suspensions were evaluated. Suspensions of the proteins were tasted to determine whether they were bland, mildly flavored, or off-flavored. This review led to the identification of a set of about 16 protein concentrates which were suitable for further development of the dehydrated spread prototypes.

The vitamin-mineral mix used in tablets (Table IX) was tasted in several spreads, and found to be bland. It was therefore included as the standard mix in the dehydrated spreads. The caloric content of the dehydrated spreads was adjusted, as needed, by inclusion of a suitable emulsifiable fat and a mixture of carbohydrates which produced the desired consistency.

The composition of eight spreads which fulfilled all specifications is shown in Table XVI. These included the three chicken spreads, Nos. 66C, 71C, and 73B; the cheese spreads, Nos. 67A and 72B; chili spread No. 63B; and ham spreads, Nos. 76A and 77A. All of these spreads are considered of suitable quality for use as nutritional and palatability supplements on the shelter rations.

d. Analysis, acceptability and stability of dehydrated spreads: The calculated analysis and ingredient costs of the eight spreads are shown in Table XVII. The table also shows hedonic taste ratings for the spreads, as obtained on ration cracker.

The analysis was based on the best analyses obtainable for the ingredients. The hedonic ratings indicated satisfactory flavor and physical properties. In all cases, the judges noted that the spreads improved the acceptability of the ration cracker.

The spreads supply the needed amounts of protein and fat, and also, since they are enriched with vitamins and minerals to the same extent as the tablets, the required quantities of these nutrients. The amino acid analysis of the spreads was not calculated, but since the spreads are, in general, richer in high-quality animal proteins than the tablets, it is probable that they are not deficient in essential amino acids.

The ingredient costs in Table XVII are based on maximum-quantity, bulk-shipment quotations obtained in May 1965. With the exception of one figure, which was considered unrepresentative because of a temporary price situation, they ranged from 32 to 49¢/lb, which is higher than the cost of supplement tablets. However, the higher cost of spreads was due to the necessity of including proteins with more specialized flavor and physical qualifications, as well as high-quality flavoring agents.

Preliminary evidence on the stability of spreads was obtained by storing 25 of the best protein ingredients used in spreads, for two months at 120°F. The fine-ground, dry protein concentrates were stored in sealed glass jars, which they filled about three-fourths full. Following storage, the concentrates were moistened, and taste-rated against control samples stored at 0°F. Fifteen of the concentrates showed no change in flavor, seven became slightly stale, and three developed definite off-flavors. Most of the protein concentrates therefore appeared highly stable for use in dehydrated spreads.

A second preliminary stability test was run on five prototype dehydrated spreads, based on spread No. 57 (Table XIII). These spreads contained the same chicken, cheese and chili flavors as the completed spreads

shown in Table XVI. They were packaged in jars, stored for two months at 120°F, and tasted against 0°F controls, in the same manner as the protein concentrates. The color became yellow or brownish, and the odor and flavor became definitely toasted or burned in all samples stored at 120°F. These changes were believed due to protein-sugar reaction and to deterioration of labile flavoring materials. They indicated that deterioration in storage will be a serious problem with dehydrated spreads.

B. Revised Carbohydrate Supplements

Mint-type and agglomerated starch revised carbohydrate supplements were developed, which satisfied the need for an item with softer consistency than the present supplement.

1. Mint-type supplements: At the present time a carbohydrate supplement in the form of a hard candy is stocked in shelters. Inclusion of this item in the diet effectively cuts down the total intake of protein. However, physical form of the carbohydrate supplement is unsatisfactory, in that it is excessively hard and can cut the mouth when broken. The development of softer carbohydrate supplements was therefore undertaken, as part of the project. Satisfactory mint-type and starch agglomerate formulations were prepared.

The mint-type supplements were evolved from conventional candies. We investigated reduction of the moisture in several kinds of candy to less than 2 per cent, in order to prolong their shelf-life. Some progress was made by including emulsified fat in items, such as gum drops and caramels, to prevent excessive hardness. However, no entirely satisfactory physical consistency was produced.

Grained crystal mints were made soft at low moisture content by another technique: inclusion of more than the usual content of invert sugar. When it was properly drawn and crystallized, the product CH-24, containing 15 per cent invert sugar on a dry weight basis, and 1.8 - 2.7 per cent moisture, was tender and easy to chew. However, CH-24 developed a burned flavor on accelerated storage, and the invert sugar appeared responsible for this flavor.

The mint formulation, CH-26, was free of the above objectionable flavor development, and was as soft as CH-24 at low moisture levels. Unlike CH-24, CH-26 was not drawn; physical structure was obtained by precipitation of sugar from a warm suspension of fine ground confectioner's sugar. The procedure for preparing CH-26 is shown in Appendix A-5.

Coloring and flavoring of CH-26 was investigated, but a noncolored product was preferred. Unflavored and peppermint flavored versions of CH-26

were stored for two- and four-month periods at 100°F and 120°F. Following storage, unflavored CH-26 showed negligible deterioration, and a lightly peppermint-flavored formula only a slight flavor loss. These two forms of CH-26 are therefore highly stable, and are considered satisfactory revised carbohydrate supplements. Composition, estimated cost, and average hedonic ratings are shown in Table XVIII.

2. Starch agglomerate-type supplements: Loosely bound compositions of precooked starch were investigated as a second possibility for a revised carbohydrate supplement. The first supplements developed were wafers, made from precooked starch, bound with a small amount of flour. The flavor of the wafer was unsatisfactory, and compressed tablets of precooked starch appeared more promising.

Agglomerated starch tablets were made from 18 - 20 U.S. Standard screen size granules of corn and wheat starches, precooked and dried in the laboratory, and from industrially prepared precooked rice and tapioca. The moistened granules were tableted with a sorbitol binder, and then redried. The general procedure for preparing starch agglomerate tablets is detailed in Appendix A-6.

Wheat starch was removed from the starch agglomerates because of its off flavor, and precooked potato was added for texture. The composition and ingredient costs of the best formulas developed, CH-34B and CH-37, are shown in Table XIX. The unflavored formulas were stored in sealed containers for two months at 100°F and 120°F. They showed essentially no changes at 100°F, but developed slight toasted colors and flavors at 120°F. The storage stability was therefore of a high order.

Acceptability of CH-34B and CH-37 was considered satisfactory. The texture was crisp, but not hard, and the tablets were pleasant to chew. Taste of the unflavored formulas was bland, but acceptable. The flavor of CH-37 was later improved by adding 1 per cent of dark molasses, and then toasting. Both of the unflavored formulas, as well as flavored CH-37, are considered satisfactory revised carbohydrate supplements. The calculated protein content is about 3.3 per cent, and they remain excellent diluents for protein in the rations.

C. Summary of Estimated Costs of Supplements

The estimated ingredient costs of the supplements, which have been presented in the preceding tables, and in the text, are summarized in Table XX.

Because they must contain good quality protein at a high level, all of the nutritional supplements cost considerably more than the fallout shelter rations. However, the tablets are a cheaper form of supplement than the dehydrat d spreads. This is because the spreads must contain dispersible, highly bland proteins, which cost more than the soy and peanut proteins, and casein, which are the basis of the tablets. The spreads must also be specially flavored. The ingredients for the tablets cost 25 to 30¢/lb, and those for the spreads cost 30 to 45¢. On this basis, tablets could be provided to shelter occupants for under 6¢/day, and spreads for under 10¢. The cost figure, 79.2¢/lb for ham spread No. 77A is not representative, since one of the main ingredients is still manufactured only on a pilot plant scale.

Mint-type revised carbohydrate supplements, which consist almost entirely of sugar, cost 10.9¢/lb on an ingredient basis, and can be fed for a little over 2¢ a day. Tableted starch agglomerates are more expensive than the mints, since they require precooked potato, tapioca and rice as main ingredients. CH-37 costs over 40¢/lb. However, this price is based on the wholesale cost of Minute Rice and Minute Tapioca, the marketed General Foods Corporation products. These tablets will probably be considerably cheaper, if the ingredients are produced on a special contract basis.

D. Plan for Biological Evaluation of Supplemented Rations

The original plan for the project called for physiological comparison of unsupplemented and supplemented rations, by means of rat-feeding studies. These studies included: determination of the efficiency of protein for growth (biological value); energy balance studies to measure physiological fuel value; and studies of the effects of water intake, and of food and water intake patterns, on the efficiency of energy utilization.

A detailed plan was developed for these studies, and a rat-feeding program was arranged for them. This program included all of the feeding tests except that which determines biological value; it was to be run in an outside laboratory. The program involved alternate feeding tests for two groups of 108 rats each, over a calendar period of seven months. Because of the changing emphasis of the program, biological evaluations were not carried out.

The original plan for the feeding studies is summarized in Table XXI. We believe that such a series of tests should be run and would be of great future value for demonstrating the effect of nutritional supplements on the rations.

III. DISCUSSION

A. Applicability of Nutritional Supplements

Fallout shelters throughout the country are currently stocked with supplies of ration biscuit, cracker and wafer. These items have a long expected stability, and should remain in edible condition for a number of years. Supplements for the rations are a more practical solution to any deficiencies in nutrition or palatability which the rations may have than replacement of the rations.

In both the tablets and spreads, we have developed supplements which can be used to make the rations a complete diet. However, the supplements are highly concentrated, and they must be used with care. Such use can probably be obtained by marking the supplements distinctly, and by placing them under the charge of shelter leaders. Allotment of extra quantities to individuals requiring special nutrition could be carried out at the discretion of the leaders. Control over the amount of supplement consumed might be somewhat better with tablets than with spreads, because tablets are consumed as separate food items and are not designed to enhance palatability.

Nutritional specifications for the supplements were based on average analysis of a mixture of the three rations. However, the analyses of biscuit, cracker and wafer are not very different. A single analysis for the supplement should then make it reasonably suitable for use with any one of these three individual items.

B. Spreads for Palatability

Lack of palatability is a serious problem with the present rations. Certainly the development of materials to spread on the rations, vary their flavor, and make them taste better, appears to be a direct solution to this problem. However, the technology of spreads designed for shelter use is difficult, particularly if they are to be highly nutritious.

Canned, water-based spreads were not studied, because they appeared expensive and bulky, and because of the nutritional losses expected in sterilizing. Nevertheless, investigation of items of moderate moisture content, flash-sterilized and bag-packed might still be worthwhile.

Considerable effort was made to develop dry, ready-to-eat spreads since they are directly usable in shelters. This was not practical, because no suitable spreading agent could be found in which the nutritional materials

could be suspended. Fats and carbohydrate syrups are the only dry-spreading agents of which we are aware, and these had to be used in excessive quantities. The technique of filling granules of protein with fat and suspending them in syrup was the one which produced the highest protein ready-to-eat spreads. Possibly the protein content of such spreads could be raised still further. Also, the addition of a very small amount of water in the shelters would soften spreads which are too thick. The stability of fat and protein encapsulated in dry carbohydrate, is probably very high.

Dehydrated spreads, for reconstitution by shelter occupants, were a solution to the technological problems. Even among the protein concentrates, a wide range of ingredients was available. It was easy to introduce fat and adjust carbohydrates for consistency. Bland minerals could be used, and coated vitamins did not impart flavor to the spreads, even in mixtures which stood for several hours after they were moistened. However, flavor was a serious problem with dehydrated spreads, and it would probably also have been one with other types.

The spreads alone must taste good, which means that high-quality flavoring ingredients must be used and that other ingredients must be either bland or the flavor masked. If the spread is to improve the flavor of the rations, its flavor must be distinct enough so that it can be detected on the rations, and it must be harmonious. We found that only certain flavors were compatible on the rations, and that flavor which was appealing on one ration was not necessarily attractive on the other two.

Widely popular flavors should be used, and the levels should not be so high that they are tiring. The flavors selected answered these qualifications, as far as our tasters were concerned, but further development of the spreads will require tasting by considerably larger groups.

C. Spreads vs. Tablets

Possibly spreads are the only way to make rations more acceptable. On the other hand, the rations may be acceptable over long periods of time if they are only nutritionally supplemented. It is well known that rats and other laboratory animals will soon go off feed on a deficient diet. If supplementation can be done successfully with an austere item such as the tablets, the tablets should be used in preference to spreads. The following are the probable advantages of tablets over spreads;

1. They are easier to use in shelters.

2. They cost less.

3. They have greater stability.

4. The flavor problem is more easily solved.

IV. SUGGESTED FUTURE RESEARCH ON SHELTER SUPPLEMENTS

The following future research should be conducted on the supplements developed in this project:

1. The tablets should be taste-tested with a large taste panel, and the texture and flavor adjusted for maximum acceptability, if necessary.

2. The flavor survey on spreads should be widened to a consumer panel basis, to determine more accurately the most suitable spread flavors.

3. Spreads having the above flavors should be prepared.

4. The spread ingredients and packaging should be adjusted for maximum stability.

5. The biological tests on tablets described in Section II-C above should be conducted.

6. Shelter occupant tests should be conducted, to determine whether spreads or tablets are a more effective ration supplement.

7. The two types of carbohydrate supplements should be field-tested and the better selected.

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APPENDIX A-1

METHODS FOR ESTIMATING BIOLOGICAL VALUE OF PROTEIN MIXTURES

1. The amino acid analysis of a mixture consisting of 50 per cent supplemental protein and 50 per cent of equal parts of the proteins of biscuit, cracker, and wafer is calculated. The analysis is rated numerally against that of a standard protein of optimum biological value, namely the protein of whole human milk.

2. Individual amino acids in the supplemental protein are rated "plus", "0", or "minus", depending upon whether they produce an analysis better than that of human milk protein, better than that of ration proteins, or poorer than that of ration proteins, when supplemental protein is added at a level of 50 per cent of the total protein.

3. Individual amino acids in the supplemental protein are rated "plus" and "minus", depending on whether or not ration plus supplement can fulfill the human amino acid requirement at 40 g. of total protein per day.

APPENDIX A-2

PROCEDURE FOR PREPARING TABLETED SUPPLEMENTS A6-4 AND A7-2

1. Weigh out coarse ground ingredients of base (casein, soy, peanut, potato, and bean bread). Mix.

2. Warm to 140°F

3. Add melted fat, dropwise with stirring.

4. Hold mixture 30 min. at 140° - 150°F for absorption of fat. Stir occasionally.

5. Cool to room temperature.

6. Spread in shallow layer (about 1/8 in.).

7. Spray with fine spray until about 8.6 g. water per 100 g. of mixture has been added. (Spray was delivered in three blasts. Batch was mixed and respread after each blast. Entire water addition took 10 min.)

8. Hold moistened batch in sealed jar at room temperature for 30 min. Mix occasionally.

9. Add binder (consisting of sorbitol plus methionine and vitamin-mineral mix) and mix by turning.

10. Immediately tablet 10 g. portions of complete batch in Carver press, using 1-1/4 x 1-1/4 in. dished steel mold 3,000 lb. total jack pressure and minimum dwell time.

11. Dry tablets 16 hr. at 125°F in circulating air oven.

APPENDIX A-3

PROCEDURE FOR TASTE TESTING STORED SAMPLES OF TABLETED NUTRITIONAL SUPPLEMENTS A6-4 AND A7-2

Four taste tests were conducted on separate days: (1) on A6-4 stored for two months; (2) on A7-2 stored for two months; (3) on A6-4 stored for four months; and (4) on A7-2 stored for four months. For each test, a panel of five experienced tasters was drawn from the same group of seven members of the Food Technology Section. Each test was conducted as follows:

1. Three samples of the stored tablet were code marked as follows: A. samples stored at 0°F; B. samples stored at 100°F; and C. samples stored at 120°F.

2. The taste testers performed their evaluations individually on the code marked samples, which were not otherwise identified.

3. Each taste tester was given an instruction sheet, requesting that he evaluate the samples for odor, flavor and texture, according to the 10-1 hedonic scale of Dawson and Harris.[9] The meaning of the numerical point system of these authors was shown on the instruction sheets.

4. Obvious differences were observed in the qualities rated; also the numerical scores differed distinctly. Therefore, the scores were analyzed mathematically only, and a statistical evaluation was not made.

APPENDIX A-4

PROCEDURE FOR PREPARING FATTED GRIT SPREAD

1. Grind and screen defatted soybean grits to 100 per cent through No. 30 and on No. 50 U.S. Standard sieves.

2. Weigh out 100 g. of 30 - 50 grits and hold 15 min. in a bottle in oven at 55 - 60°C.

3. Melt hydrogenated cottonseed oil,[a] pour 20 g. in bottle of grits and stir well.

4. Hold bottle of grits plus fat 1/2 hr. in 55 - 60°C oven. Mix occasionally.

5. Let cool for 2 hr.

6. Add 100 g. corn syrup[b] and mix well.

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a/ "Keap," 41 - 43 , melting point, Hunt-Wesson Industries, Chicago, Illinois.

b/ "Karo," Corn Products Company, New York, New York.

APPENDIX A-5

PROCEDURE FOR PREPARING MINT-TYPE REVISED CARBOHYDRATE SUPPLEMENT CH-26

1. Weigh out 50 g. of water and add 100 g. of confectioners sugar.[a/]

2. Cook to 250°F.

3. Remove from heat, and stir slightly, until batch starts to crystallize and thicken. Flavoring can be added at this point.

4. Pour on marble slab and allow to cool. Batch is held by aluminum mold, to a layer about 3/8 in. thick.

5. Cut into 1-1/4 x 1-1/4 in. squares. (Weight of 1 square, approximately 13 g.)

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a/ C and H Confectioners Powdered Pure Cane Sugar, California and Hawaiian Sugar Refining Corporation, San Francisco, California.

APPENDIX A-6

PROCEDURE FOR PREPARING STARCH AGGLOMERATE TABLETS

1. For laboratory precooked starch granules:

(a) Warm 40 per cent suspensions of corn and wheat starch in double boiler until thick.

(b) Autoclave 30 min. at 14 - 15 psi.

(c) Cool and cut into slices about 1/4 in. thick.

(d) Dry for 16 hr. at 140°F.

(e) Grind and sift to No. 18 - 20 U.S. Standard screen size.

2. Factory cooked rice, tapioca and potato are ground and sifted to No. 18 - 20 U.S. Standard screen size.

3. Add 8 g. water per 100 g. of granular starchy material.

4. Immediately add 3 - 5 g. of powdered sorbitol per 100 g. of dry ingredients.

5. Tablet in 1-1/4 x 1-1/4 in. die at 500 - 2,000 lb. jack pressure.

6. Dry tablets 16 hr. at 125°F.

7. Tablets measuring 1-1/4 x 1-1/4 x about 1/2 in. weigh approximately 8.8 g. each.

SUMMARY

Supplements have been developed to widen nutritional choices and to enhance the acceptance of present stocks of fallout shelter ration biscuit, cracker and wafer. When used as directed, the nutritional supplements -- (a) and (b) -- will provide all recognized adult maintenance requirements for protein, amino acids, vitamins, and minerals.

The concept of nutritional enrichment is designed to make the rations a more nearly complete diet for extended periods of maintenance, and to provide a supply of extra nutrients for individuals with special nutritional demands. Nutritional supplements have been designed to supply 25 per cent of the total calories of a 1,500 cal/day diet, and shelter rations will make up the remaining 75 per cent. Composition of the supplements was based on average analysis of a mixture of equal parts of survival ration biscuit, cracker and wafer. These supplements, in combination with the rations, are required to meet an adult's maintenance requirements for all nutritional factors for which the National Research Council has defined a need, i.e., protein, essential amino acids, and the essential vitamins and minerals.

These supplements are of three types: (a) nutritional tablets, (b) nutritional, palatability-enhancing spreads, and (c) readily-consumed, soft-textured carbohydrate supplements.

Nutritional Tablets

The supplements developed primarily for furnishing nutritional adequacy are in the form of an austere tablet, which is intended to be packaged in the same manner as the rations, to resemble them in flavor and texture, and to be eaten either with the rations or separately. Two formulas, designated as A6-4 and A7-2, based on casein and soybean grits, are suggested as shelter items: A6-4, containing defatted peanut meal; and A7-2, made with a high protein bean bread. Both formulas are made by absorbing fat in a granular base, moistening, adding powdered ingredients as binder, compressing in a 1-1/4 x 1-1/4 in. die, and drying to less than 5 per cent moisture.

Formulas A6-4 and A7-2 had good acceptability and a high degree of stability. Taste test panel ratings for flavor and texture were only slightly decreased by four months' storage in sealed containers at 100°F. The tablets became slightly toasted after storage at 120°F for this period, but not stale or rancid. Loss in thiamine and increase in peroxides were negligible at either temperature. A slight but not organoleptically perceptible increase in free fatty acids occurred.

Nutritional and Palatability Enhancing Spreads

Spreads, which will be applied on the rations, have been designed for nutritional enrichment, and, at the same time, enhancement of palatability. Ready-to-eat spreads were abandoned, because satisfactory spreading consistency could not be developed in a composition which possessed all the required nutritional values. However, these dual objectives were approached with spreads of fat-filled soybean grits, having corn syrup as a spreading medium.

Eight satisfactory nutritional-palatability spreads were developed, in the form of dehydrated mixtures; these can be reconstituted by stirring with an equal quantity of water. The flavor of these spreads was based on a survey of the flavor compatibility of a wide variety of prototype spreads with the rations.

The eight dehydrated spreads were flavored with chicken, cheese, chili and ham. The dehydrated mixes reconstituted readily, to give spreads with satisfactory consistency and appealing flavors, which improved acceptability of ration crackers. However, preliminary stability tests indicated that special precautions will be needed to prevent flavor loss and off flavor development during long-term storage.

Austere tablets are a more promising ration supplement item than flavor enhancing spreads. The tablets will probably be less expensive than the spreads, and can be more easily handled by shelter occupants. The stability of tablets is greater than that of spreads, and the flavor more widely acceptable.

Soft-Textured Carbohydrate Supplements

Two satisfactory forms of revised carbohydrate supplement, which are easily chewed and do not cut the mouth, were developed. Mint-type supplements were made from precipitated sugar, and starch agglomerates from tableted granules of precooked cornstarch and precooked potato, tapioca, and rice. The former were suitably flavored with peppermint, and the latter with molasses. Both forms appear to have high storage stability.

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13 ABSTRACT

Midwest Research Institute has developed nutritional supplements for consumption with presently available shelter rations. When consumed as directed, these supplements will supply all the nutritional factors recognized by the National Research Council as essential for the maintenance of adults. They will extend the use of shelter rations to shelter occupants who require special feeding, and to the general population, during the post-attack period. The supplements are of two types: unflavored compressed tablets; and dehydrated spreads, flavored so that they will enhance the palatability of ration biscuit, cracker, and wafer. Accelerated storage tests indicate that (a) the tablets have a high expected shelf life and (b) the flavor of the spreads should be further stabilized.

New mint-type and tableted granular starch carbohydrate supplements have been developed, which are soft-textured and fully compatible with the mucous membranes of the oral cavity.

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