Applications of Aerospace Technology in Industry

A TECHNOLOGY TRANSFER PROFILE

FOOD TECHNOLOGY

ACKNOWLEDGEMENTS

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APPLICATIONS OF AEROSPACE TECHNOLOGY IN INDUSTRY

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FOOD TECHNOLOGY

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TABLE OF CONTENTS

TABLE OF EXHIBITS

1.0 INTRODUCTION

Food is undoubtedly the single most important consumer item in existence, not only because it is a necessity of life, but also because it is an important source of enjoyment for most people. The food industry is, of course, our largest industry, and will probably continue to be the largest. During the past 50 years, especially the last 20-30, the industry has undergone some enormous changes. The consumer is no longer required to purchase fresh foods daily, but instead can obtain a major portion of his meal items in some sort of preserved state and can keep them almost indefinitely. This trend is a result of new technology in preservation techniques, whether it be the use of canning, freezing, dehydration, freeze-drying or preservatives. Convenience foods, as these may be called, are playing an increasingly important role in the average consumer's diet. Many people are willing to pay a little extra in order to avoid spending longer hours in meal preparation. Convenience foods are not without hidden costs, however. Nutritionists and even consumers are beginning to question the effects of the additives which are used to prolong the useful life of food and are also concerned about the effects of preservation techniques on the nutritional value of food.

The food industry has a necessarily strong hold over the food items it produces. While the industry operates in a highly reputable fashion as demonstrated by its desire to retain nutrients and prevent contamination of food, it has not taken the initiative to perform in-depth scientific studies on the effects of processing, preserving, and additives on the value of food. Although consumers have strength in their purchasing power, they have essentially used this power only to choose among the various competing products. Many purchases are based on food appeal -- attractive packaging and taste from previous experience.

Only recently has a substantial number of people become aware of the possible damages of additives and the importance of nutrition. As this interest grows, industry will have to respond with more careful consideration of the health aspect of food.

The National Aeronautics and Space Administration has gained a good deal of knowledge about food processing, preservation, and nutritional value which may prove valuable to both the food industry and the consumer. NASA has had extremely rigid requirements for the food it supplies to astronauts. In simple terms these requirements are:

- the food must be extremely clean, i.e., free from bacterial contamination;
- it must be of high, known, nutritional value;
- it must be stable without refrigeration under wide temperature variation for abnormally long periods of time;
- and, finally, it must be amenable to fast, reliable, and fool-proof preparation.

Each of these requirements must be met in order to help assure successful space missions. Any type of food system failure would have grave consequences: the mission could have to be cut short, or, in the case of severe food poisoning, the astronauts' lives could be threatened. As a result, NASA has taken extreme precautions in assuring that the food is consistently high in quality and appropriate for consumption in the space environment. The precautions have led to the development of new and improved methods of processing, preserving and sterilizing food that should be of significant value to the food industry and consumers. In addition, NASA has funded numerous nutrition studies which have been, and will be, beneficial to the understanding of the nutritional requirements of man.

2.0 THE FOOD INDUSTRY AND THE CONSUMER

2.1 Dimensions of the Food Industry

The food industry encompasses a vast number of people and functions. Taken as a whole, the food industry (not including farming) comprises the largest single segment of the United States economy. The industry is characterized by the following:[1]

- Food manufacturing was an $88-billion industry in 1970, the largest single manufacturing industry. (Together with beverages, the industries accounted for shipments of $104-billion.)
- Wholesale business in groceries is estimated at $92-billion in 1970, the largest segment of wholesale business.
- Retail sales of food stores in 1970 are estimated at over $75-billion. Eating establishments did an estimated $22-billion of business in 1970.

U.S. consumers spent over $110-billion for food and beverages in 1970; over $500 for every man, woman and child. Expenditures of food products accounted for almost 17% of the consumer's disposable income, second only to housing expenditures. By 1980, consumer spending for food products is expected to rise to about $175-billion, although higher prices are expected to account for approximately one-half of this rise.

The food and beverage industry is comprised of over 32,000 establishments employing over one and one-half million persons. Food is distributed through some 40,000 grocery wholesalers; 137,000 food stores; 236,000 eating and drinking places; and 4-million food vending machines.

2.2 The Impact of Technology on the Food Industry

The production of food has one of man's earliest occupations. The evolution of food production from the individual plots cultivated for home

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[1] Source: U.S. Department of Commerce; Bureau of the Census and Bureau of Domestic Commerce.

consumption, to markets and general stores featuring fresh produce brought daily by farmers for "processing" in the home kitchen, to the modern supermarket of today with its variety of fresh, processed, and ready-to-eat foods is the result of a long series of technological advances. The results of these advances are evidenced in a variety of ways such as the availability of strawberries in North Dakota in December, delicious ready-to-eat foods in a package, and the compact nutritionally-balanced foods for long space voyages. As a dramatic example of progress in food products, it is estimated that new items introduced over the last 10 years account for over half of the items handled in supermarkets today. (The total number of new products introduced during this time is even more impressive when one considers that the mortality of new grocery products is estimated to be between 80 and 90%.)[2]

The impact of technology has been strong in all phases of the food product-processing-distribution cycle:

(a) At the growing stage, scientific land management, chemical fertilizers, "genetically-engineered" plant and animal strains, and specialized machinery have served to increase greatly farm production and quality of produce.

(b) In the processing stage, food processing machinery and techniques have made possible the large-scale production of an appetizing variety of foods often at a cost less than that which would be incurred by preparing such foods at home.

(c) Developments in food additives have served to enhance the appeal, quality, and wholesomeness of processed foods.

(d) Research in nutrition has led to the inclusion of additional vitamins and minerals in food, to the development of appetizing food supplements, and to a greater emphasis on nutritional balance in food.

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[2] "Marketing America's Food," Economic Research Service, U.S. Department of Agriculture, Pamphlet ERS-446 (August 1970).

(e) Developments in preservation techniques have made it possible to produce processed foods which retain almost all the original nutrients, appearance, and taste of freshly prepared food yet can be preserved for long periods of time.

(f) Developments of packaging which inhibits damage through spoilage or improper handling have complemented preservation techniques.

(g) Improvements in transportation and storage have made it possible to transport fresh and processed food over long distances and to preserve freshness for long periods of time.

2.3 The Impact of Food Processing and Preservation

Some of the most significant technological impacts on the food industry have been made in the fields of food processing and preservation. Today in the United States, little food reaches the kitchen without some treatment. Fresh fruit and vegetables are perhaps the only classes of food which, during the brief period of harvest season, reach the consumer without being exposed to some manifestation of food technology. However, a few weeks later even these might come from storage under controlled temperature, humidity and atmospheric conditions.[3] Although in 1900 the United States used most of its food products in the original form, it is estimated that at present over 60% of all food consumed in this country is significantly pre-processed or pre-packed.[4] In fact, the amount of fresh fruit and vegetables consumed continues to decrease in favor of a consumption of canned, frozen, and other processed products which offer variety or some degree of built in convenience.

2.4 Food Processing and Preservation Technologies

The purpose of food processing is to preserve otherwise perishable food materials, to prepare some foods for use, and to produce compound foods of various kinds.

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[3] "Food and Food Processing," Kirk-Othmer Encyclopedia of Chemical Technology, Second Edition, p. 31.

[4] Frozen Food Factbook, 1971, p. F-1.

Most fresh foods cannot be stored without deterioration and spoilage because of the presence of enzymes in all animal and plant tissues and because of invasion by micro-organisms. Also chemical reactions such as oxidation can result in detrimental changes in some foods.

Food processing and preservation methods can be classified according to the means applied to control deterioration. Removal of water will stop most enzyme action and prevent the growth of micro-organisms, although it might not prevent some detrimental chemical changes. Thermal treatment, as in canning, will inactivate the enzymes and either kill all the micro-organisms present or at least greatly reduce their number. Hermetic packaging is then needed to prevent reinfestation. By the use of freezing temperatures, both the rate of enzyme action and the growth of micro-organisms are reduced to such a great extent that foods can be stored for long periods. Addition of chemicals may also slow down both enzyme action and microbial growth. Often combinations of various approaches are used.

2.5 Industry Trends

Despite the significant advances made in food preservation and storage in recent years, improvements are still necessary. This is best evidenced by the fact that an estimated 25% of all the world's food spoils before it can be eaten.[5] In addition, food processors realize that even the most closely controlled canning and freezing techniques affect the texture, taste, and nutritive value of foods. Consequently, if enzyme activity could be controlled by some non-heating process, it would become possible to preserve a host of products in nearly natural condition with a minimum of change in texture and other qualities of food.

Nutrition is another area which is receiving increased attention as the result of growing consumer interest. This attention involves both the re-evaluation of present food and the development of new nutritionally balanced food. The availability of nutritionally balanced "powdered breakfast" and "breakfast cakes" containing the nutrients of a complete breakfast are beginning to gain market acceptance.

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[5] "Making Isotope Markets," Chemical Week, September 24, 1966, p. 34.

The industry looks to a wider proliferation of processed foods not only as a means of increasing sales but also as a means of providing better food at lower prices. Experience has shown that food processing helps to eliminate losses from spoiled or damaged crop and livestock products and that processing can lower transportation, handling, storage and refrigeration costs. Food by-products often can be converted into commercial products with a market value. In addition processing allows crops to be grown in the areas of most cost-effective production, and spoilage cost can be greatly reduced because the processed items have a longer shelf life.[6] In fact, in a list of 115 convenience foods studied by the United States Department of Agriculture, 38 were found to cost less in processed form than in unprocessed form.[7]

The most significant trend in food marketing, however, appears to be in the area of increased variety and convenience. Seasonal or geographically localized food can be made available on a nationwide basis. Some of the latest "market accepted" foods which indicate the continuing trend toward convenience foods as well as nutritionally balanced foods include:[8] freeze-dried coffee, salad components, gravy mixes, and instant breakfasts; food which can be cooked by boiling in its plastic package; snack foods; artificial orange juice; and a number of mixes such as cheese dips, milk shakes, gravy, custards, and salads. Many of these new foods have been made possible by emulsifiers, stabilizers, and preservatives of various kinds that provide better textures or flavors or insure better keeping qualities.

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[6] "Food Prices and Marketing Trends in the United States," by George E. Millman et al, Chase Manhattan Bank (1970), p. 9.

[7] Grocery Manufacturers Association.

[8] Kirk-Othmer, op. cit.

In the area of food processing, recent innovations include:[9]

Continuous vacuum drying
Spray drying
Dehydro-frozen and dehydro-canned foods
Freeze concentration
Aseptic canning
Hydrostatic canning
Freeze drying

A number of these processes are still in the development stage or have just begun to be commercially important.

Still under development, but expected to gain market acceptance, are the use of irradiation, microwave heating and bactericidal gases for sterilization and pasteurizing.

Some of the more significant changes in market emphasis and processing techniques are given in Exhibit 2.1.

2.6 Market Sizes and Growth Rates

Consumer expenditures for processed foods have surpassed those for fresh foods; processed foods now account for approximately 60% of the consumer's food dollar. Consumers expended approximately $60-billion for processed foods versus $40-billion for fresh foods in 1969 (Exhibit 2.2).

The impact of the food processing/preservation industry on the food supply in the United States is dramatically illustrated by the fact that approximately half the U.S. acreage producing vegetable crops and nearly half of the fruit production are used for processing.[11]

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[9] Kirk-Othmer, op. cit.

[10] Kirk-Othmer, op. cit.

[11] "Canned Foods: Principal Trends in the Industry," by Milan D. Smith, National Canners Association, Food Industry Yearbook, 1965, p. 84.

Exhibit 2.1

FOOD TECHNOLOGY DEVELOPMENTS SEEN IN THE '70's

Market Factors

More rapid adoption and adaptation of continuous processing equipment from the chemical processing industry.

New era of manufacturing in which basic product components will be extracted from natural raw materials and fabricated into engineering foods.

Formulation of more foods for specific health benefits. Non-allergenic protein products are an example. Even the psychological effects of various types of foods and diets may become important as more research is done in this area. Applied nutrition research will become of prime importance.

More and better convenience foods and packages. In this decade, homemakers will be able to put varied-menu meals on the table without making a single dish themselves -- just heat, or chill, or rehydrate, and eat. It will be possible to store frozen and/or dehydrated dishes in automated appliances for pushbutton meal preparation.

Processing Factors

Terminal sterilization of dry products by gamma irradiation, microwave heating, or by bactericidal gases. Steady increase in aseptic filling of continuously cooked and sterilized foods into sterile metal, glass, paperboard or plastic containers. These will be some of the outstanding advances in the '70's.

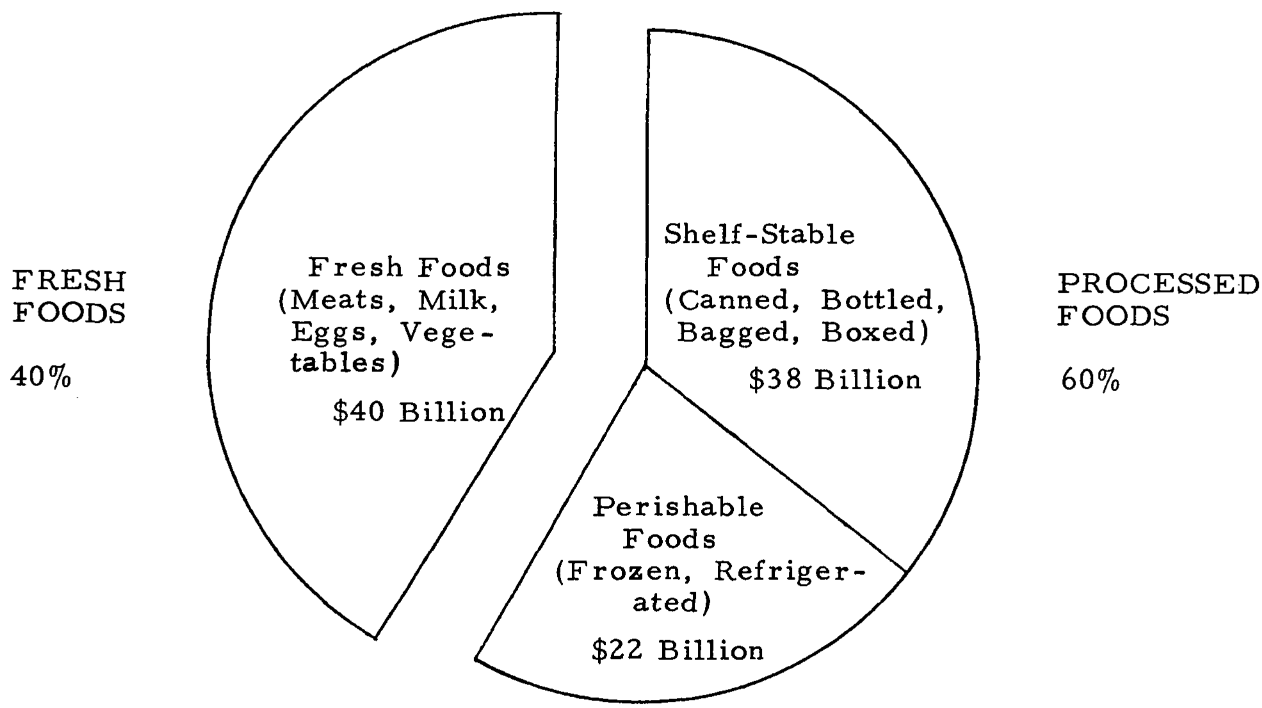
Microwave heating that effects improvements in processing. The ability to heat food "from the inside out" avoids overcooking the outside by conventional heating.

Practical employment of ionizing irradiation to do things that cannot be done, or done as well, by other techniques. Deinfestation of grain, flour and meal; inhibiting sprouting of root vegetables; sterilizing dry products; "pasteurizing" fish, meat, and poultry to extend shelf-life; and surface treatment of fruits to delay spoilage will be among the applications. Irradiation eventually will be used as an adjunct to heat processing to reduce the amount of heat required.

Source: Food Engineering, January 1970, pp. 66-67.

Exhibit 2.2

WHAT THE CONSUMER EATS . . .



Source: Ben Buchannan; "General Foods Corporation Product Development . . ." Aerospace Food Technology (NASA SP-202), p. 125.

Of approximately $100-billion expended by consumers on food in 1969, $72-billion was expended for consumption of food at home. Approximately $28-billion was spent on food consumed away from home, and consumers are expected to spend an increasing percentage of their food dollar for away-from-home consumption. High labor costs and shortages of chefs, coupled with requirements for quick and easy food preparation and rising costs of fresh foods are expected to make the institutional market an increasingly lucrative one for processed foods.

2.7 The Effect of Consumer Demands

Consumer choice is based upon product appeal. Food appeal is a very complex factor composed of taste experience, package attractiveness, name brand association, convenience of preparation, and food value. Unfortunately, consumers have not in the past demonstrated that nutritional content is the most important consideration in their choices. Consumer attitudes are changing somewhat now with the increasing nutritional knowledge and interest in health foods. Undoubtedly, the consumer will begin to exert more pressure on industry to produce food which has undergone less nutrient destruction. Consumers will also demand that labels carry more exacting information in regard to the contents of a food product. Such demands will require the food processor to produce higher quality food in order to stay in competition.

Consumers are also interested in food products such as frozen foods which do not have to be used immediately. This type of food provides a great deal of convenience because it can be stored and used whenever desired. There are several ways of preserving food for future use. Probably the oldest known method is simply drying with or without the addition of salt. One of the newest methods is freeze-drying, for which additional applications are constantly being sought. Preserved food has a significant amount of appeal and industry has been striving to satisfy the demand.

Convenience of preparation is closely related to preservation techniques. Preservation is not only a convenience in itself, but certain types of preservation can lead to simple and rapid preparation. For instance, frozen pre-cooked foods require very little work in preparation and usually result in a fairly high quality product. Not too many years ago, a typical homemaker averaged about 5-1/2 hours per day in the kitchen, cooking three meals a day for a family of four. Today she manages to feed the family well with only 11 hours per week spent in the kitchen.[12]

Consumers should, however, consider the effects of pre-cooking and preservation of foods. Is the nutritional value of the food affected? Can any of the additives be harmful? These questions cannot be answered by the consumers alone. They must look to doctors, nutritionists and biochemists for the answers. Industries which take heed of nutritional knowledge and safer methods of food preservation and production will prosper because of consumer demand.

NASA studies on nutrition and food technology should prove valuable to both industry and the consumer because of the resulting increased knowledge of nutritional requirements and because of the introduction of improved food processing techniques. The following chapters present examples of the technology that NASA has helped to advance and the impact that some of the technology has had.

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[12] Grocery Manufacturers Association.

3.0 NASA CONTRIBUTIONS TO FOOD TECHNOLOGY AND NUTRITION

Essentially all of NASA's work on food and nutrition is either done by, or funded by, the Food & Nutrition section of the Preventive Medicine Division at the Manned Spacecraft Center. The research and development work is funded in response to the need to provide the astronauts with very specialized food items. Such items are not normally available from food industries because they are not required as a necessity by the average consumer. However, the research and development work being done by the Manned Spacecraft Center is proving to be quite valuable to industry and consumer. Needless to say, this work would not be performed at such an early date if it were not for NASA's funding.

3.1 NASA Requirements

NASA advancements in food technology and in nutritional knowledge resulted from some very rigid requirements and efforts directed to meet these requirements. Examples of the criteria that the food must meet are:

(1) Physiological

highly nutritious
high caloric density
easily digested
cause no gastric disturbance
low residue
non-gas producing

(2) Appeal and Acceptability

sufficiently familiar flavor and texture to assure consumption for duration of flight

(3) Stability

biologically, chemically, and physically stable under the following conditions:

0-130°F for 100 hours
75°F for 400 hours

and under vacuum in flexible packaging (29 in. of mercury)

(4) Utility

low volume
lightweight
assured and reliable quality
reconstitute in 45°F and/or 155°F water
crumb-free at time of consumption
unaffected by spacecraft vibration

These are typical of the requirements placed on the food items. These requirements may vary somewhat depending on the particular mission, vehicle, and crew.

NASA is constantly striving to improve the food system and its components. These efforts have contributed to several advances in technology as well as improvements in existing technology. Most of the advances in food technology have occurred in the areas of preservation and standards for food processing. NASA has also funded several interesting and significant studies of nutrition. The following sections of this chapter present examples of NASA-sponsored work.

3.2 Preservation Techniques

NASA has been involved in a number of different food preservation techniques. Of these, the most prominent are: dehydration, freeze-drying, intermediate moisture, pasteurization by irradiation, and nitrogen packing. None of these methods of preserving is new, but NASA has contributed to and stimulated advances in this area.

Dehydration is one of man's oldest methods of food preservation, and it is the most widely used method of food preservation today. Much food drying is a natural process; grains, legumes, nuts, and certain fruits mature on the plants and dry in the sun and warm wind. The use of heat from a fire to dry food and to supplement the unpredictable action of the sun dates from ancient man. However, it was not until about 1795 that hot-air dehydration equipment was invented. Dehydration became important in the United States during the Civil War and the World Wars when reduction in weight and volume of food for shipment was required. Impressive progress was made in dehydration research and production methods during World War II.

A variety of different types of heat drying equipment is employed today, with the particular type of equipment used depending upon the material being dried and the nature of the processing desired.

Freeze drying is one of the most important recent developments in the food dehydration field. The drying is effected by sublimation of water under vacuum conditions without raising the product temperature. This method of food drying resulted from research conducted during World War II on dehydration of blood and biological materials.

The ability to dry without raising the product temperature is of utmost importance from a flavor standpoint; the important flavor-carrying oils are not removed by sublimation. In addition the cellular structure of the food is essentially retained so that the physical structure of the rehydrated food is about the same as that of thawed frozen food. In addition, freeze-dried foods can be stored and transported without refrigeration, they are light in weight, and they have a long shelf life.

On the negative side, freeze-drying is a slow process and the equipment required is expensive. Costs of freeze dehydration are presently on the order of four times more than those of conventional dehydration. Because of its high cost, the process is used principally for the few foods which can benefit greatly from the advantages of freeze drying, such as coffee, chicken, meat, mushrooms, shrimps, and vegetable items used in small amounts in soup mixtures. Processing costs are expected to decrease as a result of increased use and production of freeze-dry equipment.

The major differences between freeze dehydration and conventional drying methods are given in Exhibit 3.1.

The Gemini missions required the use of food that could be reconstituted in cold (approximately 80°F) water. Previously, almost all dehydrated foods required 180-200° water for rehydration. In addition, the mission required that rehydration be complete in 10 minutes. Previously, most foods required approximately 20 minutes.

In order to meet the 80°F/10 minute requirement, NASA funded work at the Army Natick Laboratories. By careful preparation of meat, development of special gravies that reconstituted at 80°F, and freeze-drying, it was possible to meet the Gemini requirements. The resulting products could be prepared much more easily than anything previously available. The Army is using some of the above type foods in long-range patrol packets. The final product surpassed the requirements and could be prepared in only 5 minutes.

Exhibit 3.1

CONVENTIONAL VS. FREEZE-DEHYDRATION[13]

Conventional Dehydration	Freeze-Dehydration
Successful for easily dried foods such as fruits, seeds, and vegetables.	Successful for most foods but usually limited to those not successfully dried by other methods.
Meat generally not satisfactory.	Successful on cooked and raw animal products.
Continuous processing.	Batch processing.
Temperatures between 100 degrees and 200 degrees F generally used.	Temperatures sufficiently low to prevent thawing used.
Usually at atmospheric pressure.	Pressures below 4mm. Hg used.
Drying time may be short, usually less than 12 hours.	Drying time generally between 12 and 24 hours.
Evaporation of water from food surface.	Moisture loss by sublimation from boundary of ever receding ice crystal zone.
Solid dried particle.	Porous dried particle.
Higher density than original food.	Lower density than original food.
Odor frequently abnormal.	Odor usually natural.
Color usually darker.	Color usually natural.
Slow rehydration, usually incomplete.	Rapid, complete rehydration possible.
Flavor may be abnormal.	Flavor generally natural.
Storage stability good, tendency to darken and become rancid.	Storage stability excellent.
Costs generally low, in the order of 2 to 7 cents a pound water removed.	Costs generally high, in the order of four times more than conventional dehydration.

[13] Adapted from Tischer and Brockman (1957).

NASA also funded a project which was designed to obtain maximum variety from a feeding unit of low weight and bulk.[14] The purpose of the research was to develop for space use dehydrated food items which would add minimal weight and volume to the spacecraft. A combination of dehydrated food bars and cubes of concentrated sauces and seasonings was developed that weighed a total of 10 pounds and could be packed in a box of 408 cubic inches (about the size of a shoe box). This 10 pounds of food could be used to prepare 32 meal items averaging 700 Kcal each. With respect to the calories per unit volume and the variety of familar foods potentially available, this food module offers advantages over any earlier food system. Such foods hold special interest for campers and mountain climbers. As a result of this technology, similar dehydrated food bars are being produced commercially by a manufacturer on the west coast. (See 4.2).

Recently, a new process has been developed by a scientist[15] under NASA contract for producing an instant rice which is truly "instant." The instant rice now makes it possible for the astronauts to have rice included in their space menus. Previous to this new process, it was too much trouble to prepare regular instant rice in space. The process involves three cycles of freezing (two hours at -14°F) and thawing of previously cooked rice. After the third freezing, the rice is freeze-dried to reduce the moisture content to a very low level. The rice is then packed and sealed under a vacuum, which insures a long shelf life.

The repeated freezing and thawing breaks down the basic structure of the grains enabling the rice to be rehydrated rapidly (and digested easily). Normal hot tap water (about 155°F) can be used for the rice -- it does not require boiling water. The process could prove very beneficial to the housewife, since the rice would require three minutes or less from shelf to the table. At least two major food companies have shown interest in the instant rice, and it may not be long before it appears on supermarket shelves.

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[14] The Pillsbury Company, Minneapolis, Minnesota.

[15] Dr. Clayton Huber (under contract to NASA), Technology Inc., Houston, Texas.

The rice has been used in the development of a chicken rice soup which was eaten by the Apollo 14 crew. Exhibits 3.2 and 3.3 show the chicken rice soup both before and after rehydration. Research is currently under way to produce in addition combinations of rice with shrimp and ham.

Besides the items already mentioned, NASA has been responsible for the development of nearly 100 different freeze-dried or dehydrated items. Examples of these items are listed in Exhibit 3.4. The standards for production of all of the food items are freely available for any manufacturer to use. Chapter 4 will give a few examples of specialized food-producing firms which have made use of the NASA standards.

A NASA contractor[16] has developed a method of keeping bread fresh and free from mold for relatively long periods of time. Bread is normally considered a semi-perishable food and unless the bread is frozen or refrigerated, the average shelf life is less than two weeks. Even with the addition of preservatives such as propionates or sorbates as allowed by the Food and Drug Administration, bread is still semi-perishable. For the Apollo program, NASA required bread that could be used over the entire mission without the danger of deterioration. Packaging of bread under a hard vacuum (29" of mercury) was tested. Although the bread had excellent stability, it was compressed in the flexible package. Because the normal texture of the bread had been destroyed, it was not acceptable for eating.

The NASA contractor developed a method which involved flushing the bread and package with nitrogen three times. Before the bread was wrapped, each package was cleaned with 70% ethyl alcohol. The bread was handled aseptically throughout the packaging procedures. Each piece of bread was packaged separately in order for it to remain in its nitrogen atmosphere until shortly before it was consumed. Samples of the bread have been stored in excess of 14 weeks with no signs of mold growth. The techniques of aseptic handling and packaging under nitrogen could be applied industrially for the distribution of bread. Although the processing is more expensive than present methods, the elimination of losses due to deterioration could more than make up for the added costs.

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[16] Technology Incorporated, San Antonio, Texas.

Exhibit 3.2 PHOTOGRAPH OF FREEZE-DRIED CHICKEN RICE SOUP

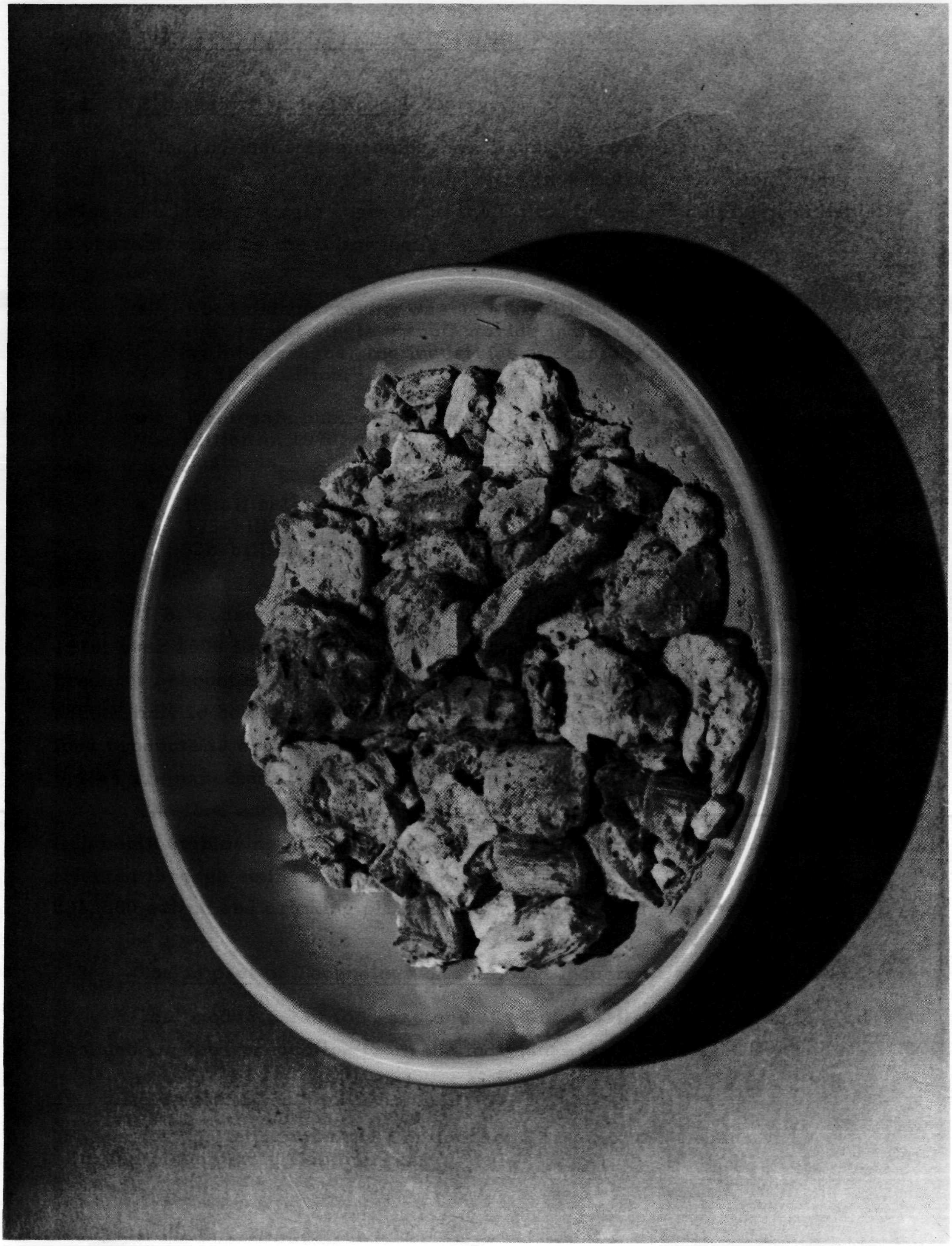

Exhibit 3.3

PHOTOGRAPH OF REHYDRATED CHICKEN RICE SOUP

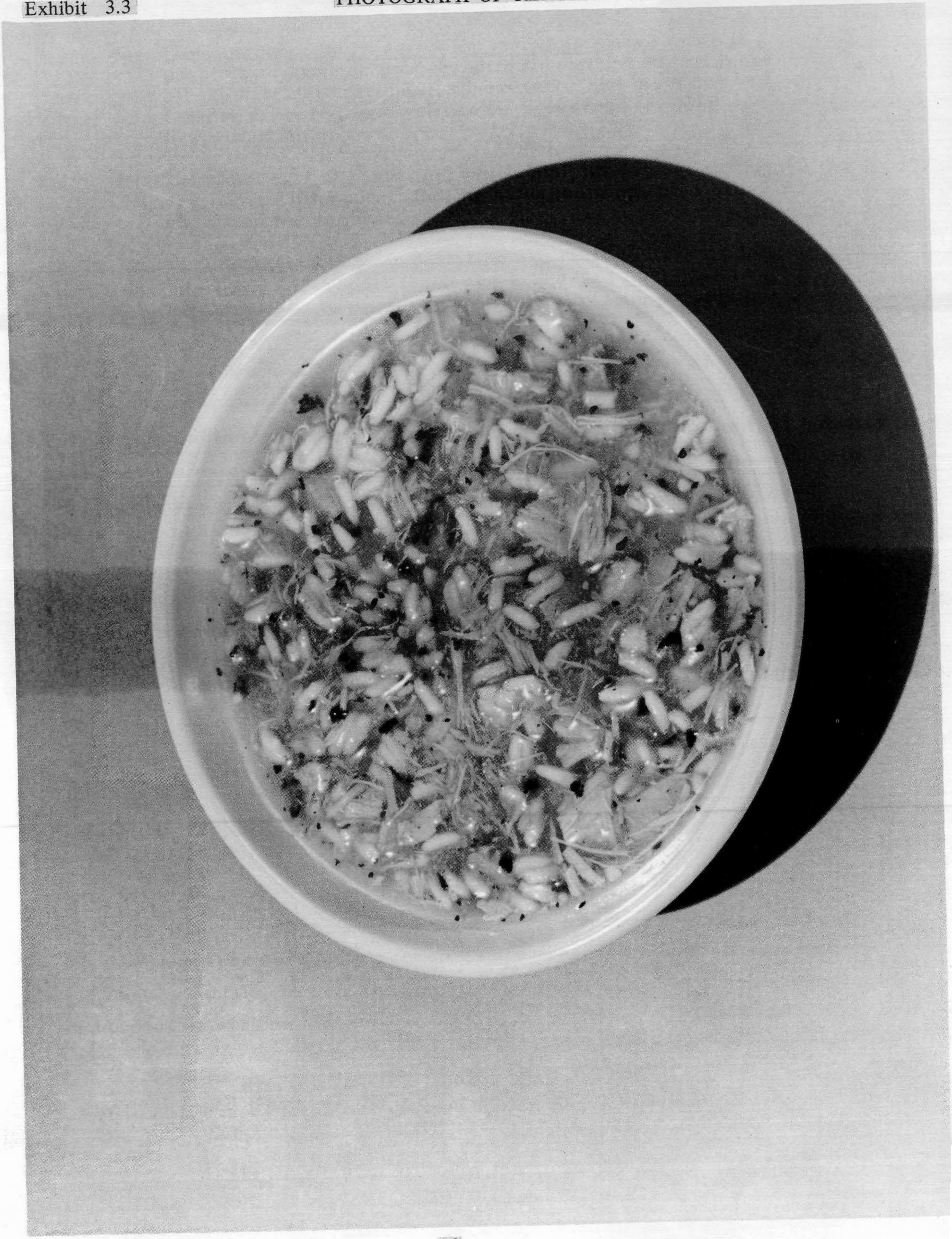

Exhibit 3.4

NASA DEVELOPED FOODS

- Applesauce, Instant
- Apricot Cereal Cubes
- Apricot Pudding
- Bacon Bars
- Bacon Squares
- Banana Pudding
- Barbecue Bite-Size Cubes
- Beef and Gravy,
- Beef Bites
- Beef Pot Roast
- Beef Sandwiches
- Beef with Vegetables
- Blue Cheese Bite-Size Cubes
- Brownies, Bite-Size
- Butterscotch Pudding
- Canadian Bacon and Applesauce
- Cereal-Fruit Cubes
- Cheese Cake Cubes
- Cheese Cracker Cubes
- Cheese Sandwiches
- Chicken and Gravy
- Chicken and Vegetables
- Chicken Bites
- Chicken Noodle Soup
- Chicken Salad
- Chicken Sandwiches
- Chicken Vegetable Soup
- Chocolate Pudding
- Cinnamon Toast
- Cocoa Beverage Powder
- Corn Bars, Cream Style
- Corn Chowder
- Cream of Chicken Soup
- Cream of Tomato Soup
- Date Fruitcake
- Fruitcake (Bite-Size)
- Fruit Cocktail Bars
- Gingerbread, Bite-Size
- Grapefruit Drink
- Ham & Swiss Bite-Size Cubes
- Milk
- Mulligatawny Soup
- Oatmeal and Farina Cereal Mixes
- Orange Drink
- Orange-Grapefruit Drink
- Oxtail Soup
- Parmesan Bite-Size Cubes
- Pea Bar, Sweet
- Peaches
- Peaches and Cottage Cheese
- Peanut Cubes
- Pineapple-Grapefruit Drink
- Pork Sausage Bites
- Pork Sausage Patties
- Potato Salad
- Potato Soup

Exhibit 3.4 (continued)

Salmon Salad

Shrimp with Sauce
(Shrimp Cocktail)

Spaghetti with Meat Sauce

Strawberry Cereal Cubes

Sugar Coated Cornflakes & Toasted Oat Cereal

Sugar Cooky Cubes

Tea, Instant with Sugar and Lemon

Toast, Plain

Toasted Bread Cubes

Tuna Salad

Turkey Bites

Vegetable-Beef Soup

Sources: See Bibliography 11, 16, 36 and Addendum No. 2A Space Food Prototype, U.S. Army Natick Laboratories, December 30, 1966.

Intermediate moisture foods are foods which contain too much moisture to be considered dry but which show definite resistance to microbial deterioration, as do dehydrated foods. Intermediate moisture (IM) foods are not by any means new. Dried dates and figs, perfect examples, were eaten by man before the beginning of recorded history. Other examples are: dry sausage, beef jerky, country ham, fruit cake, jams and jellies, and marshmallows. Because these foods contain only about 20 to 30 percent of their normal water content, they resist spoilage without the need for refrigeration.

IM foods are characterized by an index which refers to their water activity. Since all microbes require a certain amount of moisture in order to grow, the measure of water available in a substance is a good indicator of its resistance to spoilage. Most foods such as meat, vegetables, etc., have a water activity of about one. If the water activity is reduced to .90 or lower, almost no bacteria can grow; below .85 essentially no yeast can survive; and below .80 most molds cannot grow. Most IM foods have a water activity of about .25 to .70. (By comparison, most dry foods have water activities of .20 or less.) IM foods may be prepared either by dehydration or by the addition of enough dry material to sufficiently lower the water activity. For reasons that cannot be explained fully here, the materials most often added are sugar or salt. For many food items this addition may not result in a highly palatable product.

The commercial application of intermediate moisture technology was first made in the pet food area about 1965. Formerly, pet foods were available either as dried, packaged, meal-type rations containing about 10% moisture or as canned meat-like rations with about 75% moisture. The meal-type rations, while easily and inexpensively packaged, present pallatability problems, even after being mixed with water. Regular meat-type rations, on the other hand, require a canning process and, once the can is open, the contents have to be refrigerated. Based on research in semi-moist foods, a meat-like product containing between 20 and 40% moisture which could be inexpensively packaged was introduced.

While a great deal is known about IM foods, there are still many properties which are not completely understood. NASA has funded research[17] on IM foods which is aimed at developing more natural tasting foods by using additives other than salt or sugar. In addition the research is aimed at discovering ways of preventing rancidity in IM foods. Although IM foods can last for as long as 3-6 months,deterioration is usually a result of rancidity.

Improved IM foods could be very valuable for normal human consumption. They keep for long periods of time without refrigeration and require no preparation. Highly nutritious products could be developed and stored for use in emergency situations. If a disaster occurred, the food could be immediately shipped to the stricken area with no loss in preparation time and no need for refrigeration.

A complete meal in stick form could be devised. One researcher has even suggested the use of a nutritious and delicious food bar as a replacement for lollipops for children. IM foods show much promise as snack items because of their high food value and the lack of special storage requirements.

The use of ionizing radiation for the pasteurization (and consequently preservation) of food has been under examination since about 1950. Large scale practical applications have not yet occurred despite much progress that has been made in assessing the effects of radiation on food and its constituents. The Food and Drug Administration has been reluctant to allow widespread use of radiation for preserving food. Radiation has been used in the United States for preserving canned bacon and for sprout-proofing potatoes. It is expected that numerous other products will eventually be cleared for irradiation processing. Although such studies have been going on for several years, NASA's research is contributing some new and valuable information on this technique. The low-dose radiation that is required for pasteurization does not result in any detectable quality change in the food. NASA research[18] has mainly involved the irradiation

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[17] Dr. Theodore Labuza, Dept. of Nutrition, University of Minnesota.

[18] Dr. Theodore Hartung, Dept. of Food Science and Technology, University of Nebraska.

of flour and bread in order to prevent mold and bacterial growth. A single dose of 50,000 rads does not change the functional qualities of flour and increases the stability of bread. The nutrients are essentially unchanged. Exhibits 3.5 and 3.6 show samples of bread after 6 months. The irradiated flour and bread survived much better than the untreated bread.

The tests on bread and flour are not only valuable in themselves, but also provide a means for studying the general effects of irradiation on food products. Furthermore, this research helps to establish the technology of irradiation as an effective and safe means of preserving food items. Because of the advance in technology that has occurred as a result of the NASA studies, the researcher feels that FDA approval and widespread use of irradiation will occur sooner than would otherwise be possible.

3.3 Standards for the Production of Low Contamination Food

Space food provides the astronauts with the necessary physiological and psychological balance and therefore is an essential part of the life support system. The microbiological quality of the space food is most important. With millions of dollars and man hours spent to develop a space mission, a severe loss might be incurred if an astronaut were suddenly struck with a food-borne infection. Consequently extremely high safety standards have been established for the production of space foods.

These standards provide strong assurance that the food will have no adverse affects on the astronauts. The bacteriological specifications for the Apollo program are given in Exhibit 3.7. Comparable specifications are expected to be used for future space missions. The firms which produce food for NASA have established successful controls for the standard production of space foods. Exhibit 3.8 displays examples of average bacteriological counts in dehydrated space foods.

It has been found that "clean rooms" -- isolated areas where contamination is minimized -- are extremely valuable in the quality production of space foods. Manufacturing in clean rooms 1) reduces the chances of bacteriological contamination and 2) reduces the contamination by particles on the outside of food packages which must

Exhibit 3.5

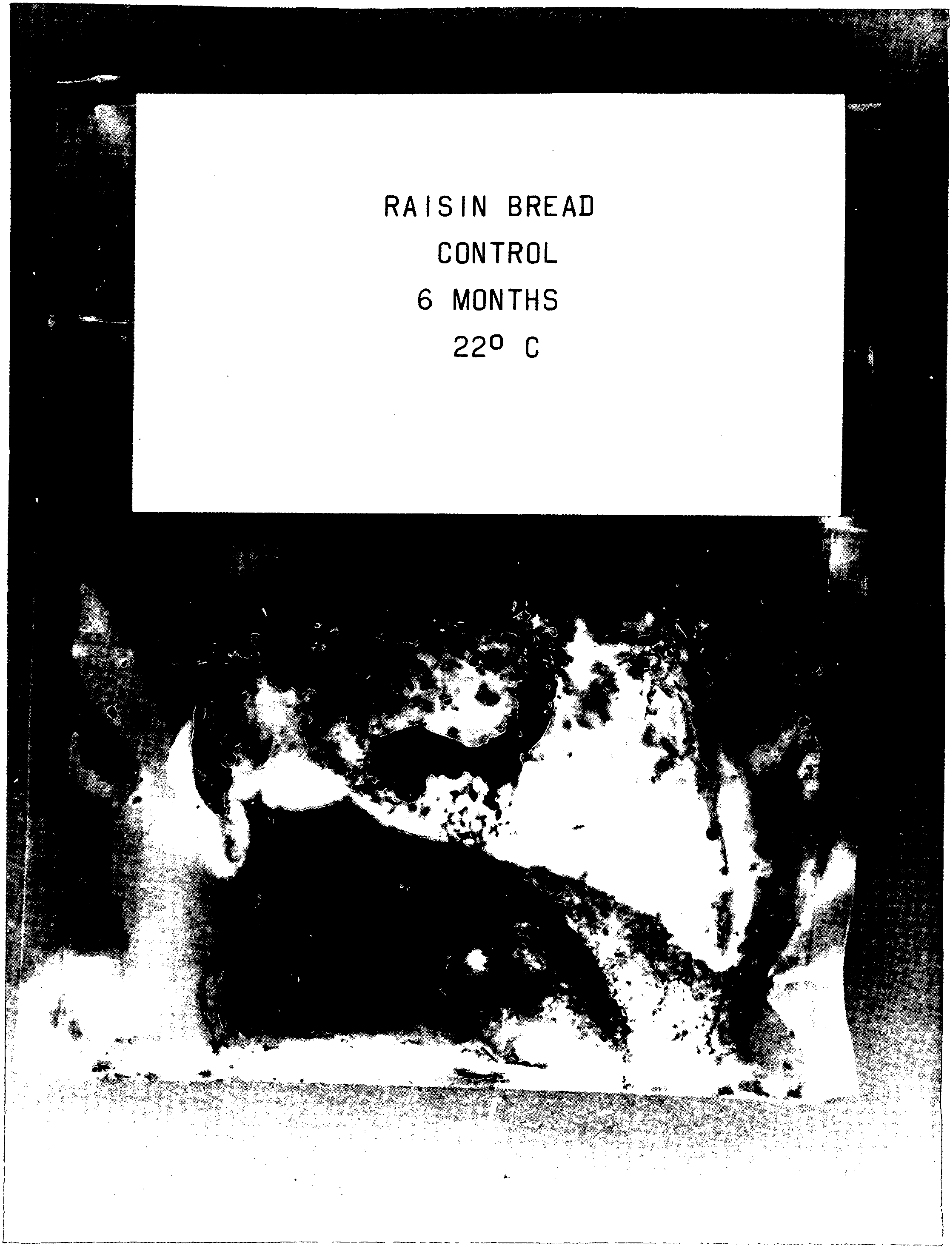

Exhibit 3.6

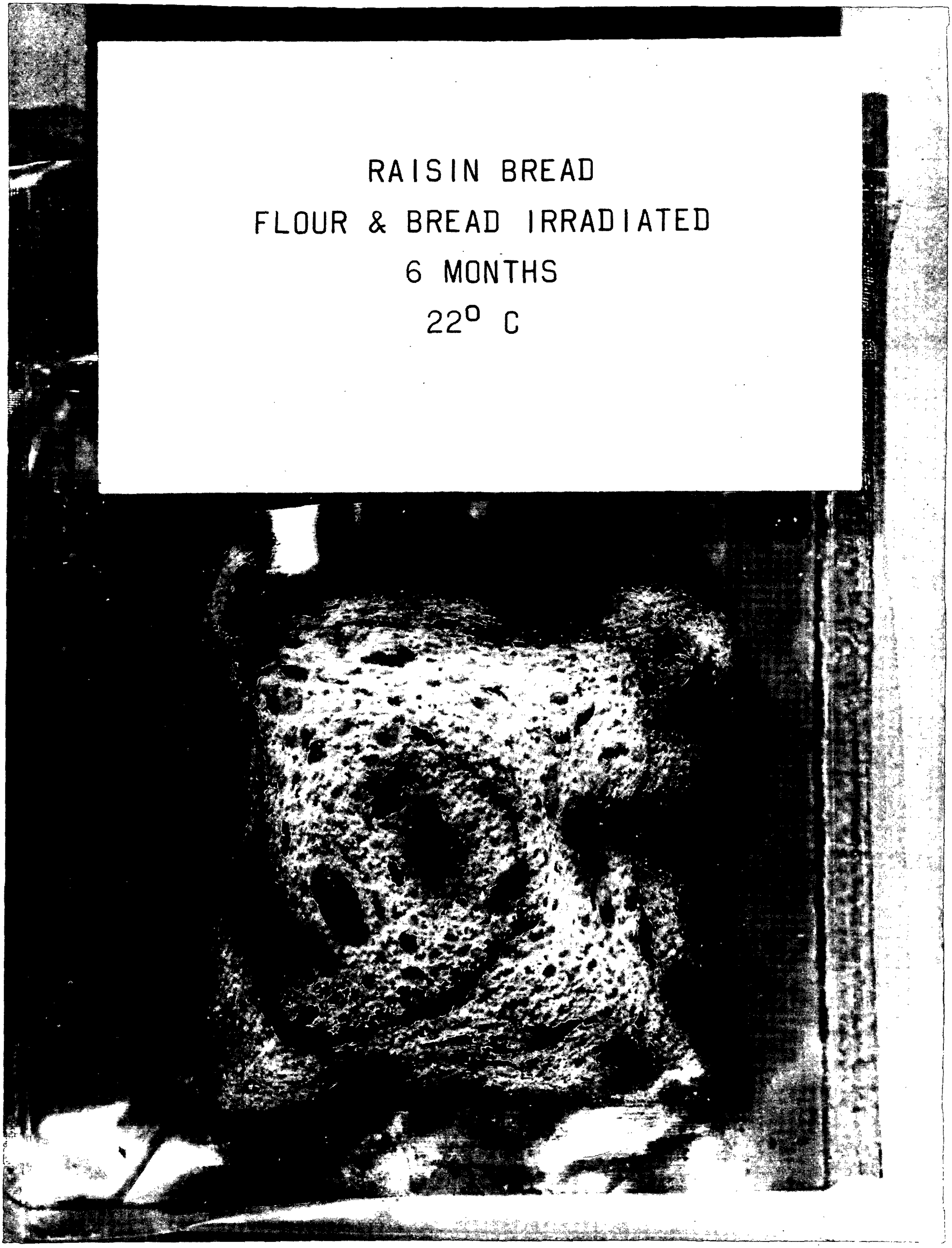

Exhibit 3.7

BACTERIOLOGICAL REQUIREMENTS FOR DEHYDRATED SPACE FOODS*

Total Aerobic Plate Count:	Not Greater than 10,000/gm
Total Coliform Count:	Not Greater than 10/gm
Fecal Coliform Count:	Negative in 1 gm.
Fecal Streptocci Count:	Not Greater than 20/gm
Coagulase Positive Staphylococci	Negative in 5 gm
Salmonellae:	Negative in 10 gm

*When determined by the methods specified by El-Bisi and Powers.

Exhibit 3. 8

TYPICAL MICROBIAL FINDINGS IN DEHYDRATED SPACE FOODS*

Food Item	Total Aerobic Plate Count/gm
Scrambled Eggs	20
Beef and Gravy	170
Potato Salad	390
Tuna Salad	3200
Chicken Salad	30
Applesauce	0
Beef Pot Roast	100
Shrimp Cocktail	1000
Chicken and Vegetable	350
Chicken and Gravy	470
Beef and Vegetable	170
Bacon Squares	860
Beef Sandwiches	100
Cheese Sandwiches	300
Chicken Sandwiches	480

*All foods were found negative for total coliform, fecal coliform, fecal Streptococci, Coagulase, Positive Staphylococci, and Salmonellae. All determinations made by the methods of El-Bisi and Powers "The Microbiological Wholesomeness of Space Foods," U.S. Army Natick Labs Report 70-41-FL, June 1969.

interface with space hardware. Initial processing of food is performed in a class 10,000 clean room (see Exhibit 3.9) to meet bacteriological requirements and final packaging is done in a class 100 clean room to meet spacecraft vehicle limits on particulate matter. The clean rooms for food production were designed on the basis of the clean rooms used for production and assembly of spacecraft parts. It is already well known that NASA has contributed a great deal in the field of contamination control. (For information, see Contamination Control Handbook, NASA SP-5076).

Food-borne diseases are still a significant public health problem; thus, clean rooms may well find valuable application in the food industry. There has been a general trend of increased centralization of food production. This trend indicates the desirability of using high safety processing techniques. Although clean rooms and the associated aseptic techniques are expensive, we can almost certainly expect them to be cost-effective in the production of a number of food items. The reduced risk of food poisoning will outweigh the increased costs of production.

One of NASA's contractors using clean rooms for space food already feels that the increased knowledge of clean room techniques has been, and will be, of significant value to the food industry (See 4.1).

In addition to establishing standards for production of clean food, NASA has also funded studies on the detection of viruses and bacteria in food. One such study involved an analysis of the stability of viruses in low moisture foods.[19] The research helped to validate an important virus detection technique. In addition it demonstrated that the shelf life of a virus in a specific food can easily exceed the shelf life of the food itself. In other words, intermediate moisture foods must have no viruses in them at production time because the viruses will not disappear before the food goes bad. The validation techniques funded by NASA were a valuable step in the process of developing virus detection methods. This is a relatively important

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[19] Dr. Dean O. Oliver, Food Research Institute and Department of Bacteriology, University of Wisconsin.

Exhibit 3.9

NON-VIABLE AND VIABLE PARTICLE COUNT* STANDARDS FOR CLEAN ROOMS

Class	Non-Viable Particles** Not to Exceed per $ft.^3$	Viable+ Particles Not to Exceed per $ft.^3$
100	100	0.1
10,000	10,000	0.5
100,000	100,000	2.5

*From NASA Handbook 5340.2, August 1967.

**Of size 0.5 microns and larger.

+ Viable particles are those which are capable of living such as bacteria or viruses.

discovery and points to the fact that rigorous food production techniques are extremely important for the production of safe foods. The validation techniques funded by NASA were a valuable step in the process of developing virus detection methods.

In another study, a NASA-funded researcher[20] performed an extensive evaluation of existing methods of detecting food-borne toxins and developed new and unique methods for the rapid detection of such toxins. The researcher compiled an extensive annotated bibliography and demonstrated the drawbacks of the existing procedures. While the new method is no longer the best one available, it showed great potential during development and demonstrates the interest that NASA has in preventing food-borne infections. Such research may prove valuable to the general public by helping to stimulate interest in the detection and elimination of food-borne infections.

3.4 Packaging

NASA has been responsible for the development of some advanced flexible packaging materials. These materials must meet many rigid requirements for use in space. Some of these are: 1) low gas transmission rate, 2) low water vapor transmission rate, 3) nonflammability, 4) ability to withstand exposure to steam or water at 240°F for 60 minutes and 250°F for 30 minutes without delamination or degradation, 5) heat sealability, 6) chemical inertness to food, 7) shelf life of at least one year, 8) optimal physical strength, and 9) transparency.

The requirements of nonflammability and low transmission to gases eliminate all of the existing packaging materials from consideration. Two new packaging materials have been successfully developed. One is a fluorinated halocarbon called KEL-F-82[21]. It is nonflammable and has a water vapor transmission rate of 0.02 gms/100 in^2/24 hrs. and a gas transmission rate of 77cc/M^2/24 hours/atmos. The other material is a laminate of polyethylene-mylar-aclar-polyethylene

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[20] Captain Richard E. Krieg, Jr., USAF, USAF School of Aerospace Medicine, Brooks AF Base, Texas.

[21] Developed by Flourocarbon Inc., Trenton, New Jersey.

called SLP-4[22]. It has a water vapor transmission rate of 0.027 gms/100 in^2/24 hrs. at 95°F and 90% RH and its gas transmission rate is 75.38 cc/M^2/24 hrs./atmos. These transmission rates are significantly lower than those of normal flexible packages.

Although these materials may be somewhat expensive for normal food packaging use, the high barrier (i.e., low transmission rates for gas and water vapor) technology which went into their development has assisted one of the manufacturers in gaining knowledge on how to bond and handle more sophisticated laminated materials. The result has been the reduction in production costs of similar materials. The pharmaceutical industry has shown particular interest in using the high barrier materials.

3.5 Nutrition

As the space missions become longer in duration it is becoming increasingly important for NASA to obtain information on nutritional requirements of man. While a dietary imbalance during a brief mission may have little or no effect on an astronaut's health, it is very important to provide the astronauts with their proper nutritional requirements during a two week-or-longer mission. Consequently, NASA has initiated several important studies on nutritional requirements and also on nutrient analysis of food items. These studies constitute some of the most advanced research being done in the field of nutrition today. The results will be valuable, not only to NASA and its astronauts, but to mankind in general.

Two leading researchers[23] in the field of nutrition have been funded by NASA for several years to study various aspects of nutritional requirements. One of the studies involves man's ability to utilize widely different levels of fat, protein, and carbohydrates. Another study on the calcium mobilization from bones in relation to work and stress may help provide new concepts on the incidence of osteoporosis, a disease involving a decrease in mass and density of

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[22] Manufactured by Milprint, Inc., Milwaukee, Wisconsin.

[23] Dr. Doris Calloway and Dr. Sheldon Margen, University of California at Berkeley, Berkeley, California.

the bones. The dynamics of calcium absorption are also being examined. Other important projects involve work on single-cell protein sources, protein losses through body surfaces, variation in nutritional requirements of individuals, the amount of energy derived from specific diets, and a 42-day study of space food diets.

NASA has funded several metabolic balance studies with particular interest concentrated on bone mineral losses. The reason for this concern is obvious -- physical inactivity such as that occurring in a weightless environment ordinarily results in definite bone mineral losses. These losses adversely affect the condition of the bones.

An expert[24] on metabolic diseases has been funded by NASA on several studies. After an initial project on basic calorie requirements, he was involved in a balance study of minerals, electrolyte, and nitrogen for the two astronauts on the Gemini-VII 14-day space flight. The study involved a controlled diet and metabolic balance studies both before and after the space flight. The project was the first extensive effort to examine body chemistry in space and the effects of space on mineral losses. Similar studies are planned for the longer term Skylab missions.

In addition to the space research, a series of groundbased studies on bed rest are being performed at the U.S. Public Health Service Hospital in San Francisco[25] under NASA funding. The purpose of these tests, which use bed rest as an analog to weightlessness, is to find treatments or procedures which can be used to counteract the loss of minerals and vitamins that occurs during space flight. So far the results have shown that:

> "Loss of bone mineral during bed rest for 6-24 weeks, assessed by mineral balance while on a diet containing 1.0 gm calcium and 1.6 gm phosphorus daily, was not prevented by the following therapeutic regimens: a) supplemental oral potassium phosphate (1.3 gm P daily), b) horizontal exercise using the Exer Genie apparatus for 80 minutes daily, c) longitudinal compression using a special suit to apply forces equal to

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[24] Dr. C. Donald Whedon, Director, National Institute of Arthritis and Metabolic Diseases, NIH.

[25] Dr. S. B. Hulley, Director, Metabolic Unit and Dr. C. L. Donaldson, Chief, Endocrine-Metabolic Service with Dr. Whedon, U.S. PHS Hospital, San Francisco, California.

body weight for up to 5 hours daily either constantly or intermittently at a frequency of 45/minute, or d) salmon calcitonin injections (100 MRC U daily). Losses of calcium and phosphorus were prevented by combined oral supplementation with calcium (0.8-1.3 gm/day) and phosphate (1.3 gm P/day)."[26]

The studies have great potential for developing corrective measures to treat demineralized bone diseases such as osteoporosis -- a common thinning of the bones that occurs in 50-70 year olds and affects approximately 14 million people in this country. The studies are also valuable for understanding the effects of extended bed rest on patients. Any knowledge of countermeasures will prove to be extemely valuable.

NASA has also stimulated development of improved diagnostic techniques for the detection of bone lesions. The technique involves the measurement of the attenuation of gamma rays in bone to determine the content of bone mineral. Such a device is very useful for determining nutritional insufficiencies which must be corrected.

It is often necessary to determine the vitamin content of food items. Presently the accepted methods for determining the amount of vitamins D, E, and K in food samples require injection of sample extracts into chick embryos. The results are not known for about 30 days and the cost of determining the amount of the three vitamins in the sample would be about $500-600. The results rely on statistical analysis and therefore can be unreliable. Although methods involving individual gas chromatography tests have been used, they still require at least a week and are expensive. Under NASA funded research[27] a method has been developed that enables an analysis of the three vitamins to be performed in one day. This method involves the use of gas chromatography, but does not require separate tests for each of the three vitamins. The vitamins can be detected simultaneously without any special chemical alterations. The cost will be

[26] Personal note from Dr. S. B. Hulley on "Therapeutic Approaches to the Prevention of Disuse Osteoporosis."

[27] Robert Erlich, Technology Inc., Houston, Texas.

on the order of $50, thus allowing nutritionists and biochemists, as well as food processors, to use the test freely.

Menu planning for institutionalized feedings involves problems of proper dietary balances. The nutritionists are faced with a similar problem when planning the meals for the astronauts. However, they are also faced with an additional constraint. The amount of food which can be carried on board the space craft is affected by weight limitations. Also, if an astronaut varies his meals from the planned menus, he may not be able to easily make up for the resulting nutritional imbalance. NASA is experimenting with a computerized menu planning.[28] The present computer program handles 72 foods and optimizes such factors as calories, protein, magnesium, calcium, sodium, potassium and phosphorous. If an astronaut varies from his menu schedule, the computer can be used to redetermine his diet plan in order to meet his nutritional requirements.

The computerized menu planning may of course be used for the initial diet plan also. Such a menu planning system could prove invaluable for the armed forces, hospitals, schools, or other large institutions which must determine menus over a long period of time.

Institutional feeding is growing rapidly in this country. Consequently a method to make menu planning more efficient could mean a significant cost savings and improved nutrition for large numbers of people. Menu planning would assist dieticians in assuring that proper nutrition was being supplied.

The success of long space flights is dependent upon the provision of adequate nutritional supplies. NASA has been examining the possibility of using formula diets which would be reconstituted from dehydrated powders during the space mission. Although the formula diets are not required until the missions become much longer in duration, the research on the diets has stimulated interest in human nutritional requirements and nutrition evaluations of food.

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[28] Technology Inc., Houston, Texas.

The diets have led to some very interesting studies because a single parameter (such as a particular vitamin or mineral content) can be varied without altering any other aspect of the diet. The experiments indicate that it is feasible to supply man with a formula diet that can maintain his health.

4.0 NASA TRANSFER EXAMPLES

The advancement of food technology and nutrition by NASA has been relatively recent. Many of the foods provided for the Mercury and Gemini astronauts were very basic in nature. They provided the necessary nutritional requirements, but were not uniformly appetizing. With the advent of longer spaceflights and with additional time for development, the Department of Food and Nutrition has produced some excellent space foods. Unfortunately, very little of the technology involved has been published as yet, with the result that the information has not had widespread availability. It is hoped this document will help to increase industry's awareness of NASA's food technology.

Despite the fact that there has been limited information dissemination, there have been a number of NASA technology transfers in the area of food technology and nutrition. While many are so general that they cannot be pinpointed, others go undocumented.

During the discussion of NASA technology in Chapter 3, many specific and general transfers were mentioned in connection with the technology. This chapter presents a few additional examples of technology transfer that were either briefly mentioned, or not even noted, in Chapter 3. Because NASA food technology is relatively new, one can reasonably expect more transfers in the future.

4.1 Impact on Industry

Swift has been responsible for the development of several space foods, especially foods containing meat. All of the Swift space food is processed in class-100 clean rooms in order to conform to NASA standards.

The opportunity to work on freeze-drying techniques for meat products has increased Swift researchers' knowledge of stability and preservation of foods. The NASA-funded work has enabled Swift to develop this technology on a research level and a spokesman[29] for

[29] Dr. R. Pavey, Swift & Company, Oakbrook, Illinois.

Swift feels that this knowledge, which is available to all industry, will show several benefits when present development work is complete. The spokesman also feels that the NASA clean room techniques will lead to improved commercial application of aseptic canning and packaging. Such techniques could eliminate the need for thermal processing of some canned foods, which normally destroys flavor, texture, color, and nutrition. In general, the Swift researcher was very optimistic about the technology generated through work on space foods.

4.2 Impact on Innovative Foods

Innovative Foods was formed to commercialize new food products and technological advances in food processing and to utilize existing processes in new ways. The company may use by-products of other processes or may synthesize products in order to achieve desired food qualities.

Innovative Foods develops and produces new food products. It sells its products to other manufacturers and the institutional trade. Proprietary processes or products developed by the company are licensed or franchised.

One of Innovative Foods' newest products is a freeze-dried, compressed food bar. Freeze-drying reduces weight from 1/3 to as much as 1/20 and compression reduces bulk by 1/4 to 1/16. The food bars are packaged in disk form. Three 1 oz. disks can serve as a complete meal when rehydrated. The advantages are that no refrigeration is required, packaging can be made simple, and the food can be instantly reconstituted or eaten as is. This product was developed partially through the use of a NASA-funded study on compressed dehydrated food bars. Innovative Foods has made use of the technology advanced by NASA, and the company president[30] has stated that the technology has been a definite aid to the new food products firm. Innovative foods sells many of its products to larger food manufacturers who sell the items under their own brand name. Innovative Foods expects the market for special freeze-dried or preserved food items to reach $20 million in the next 2-3 years.

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[30] Edward Hirschberg, Innovative Foods, South San Francisco, California.

4.3 Impact on the Artech Corp.

Due to rising pressures from both the government and consumer groups to provide consistently high quality frozen foods, there is a growing need for a device which can indicate whether a frozen food item is properly handled.

Occasionally frozen foods are defrosted during shipment with the result that the food is inferior in quality and, possibly in extreme cases, inedible. Subsequently the consumer may lose his expenditure for the food, the market may lose its patronage and the food processor may lose a customer. A device which would indicate whether a food item had been defrosted or not would be extremely valuable. A supermarket would not have to accept a food shipment unless the indicator showed no signs of defrosting. Acceptance would mean that the market assumed responsibility for care of the food and the manufacturer could no longer be held responsible for the effects of food defrosting. Similarly, customers at the market would buy only items that had not been defrosted, and the supermarket would not be responsible for any defrosting effects after the sale. The indicator would not only assure better food products, but, in case of defrosting, would pinpoint the source of the fault.

As a result of NASA-funded research, the Artech Corp. has developed a device called the Irreversible Warmup Indicator (IWI) which provides positive assurance when food has not been defrosted. The IWI has the following important properties:

1) It is activated by freezing at low temperatures.

2) Each IWI can be set to react if a given temperature is exceeded for an unsafe period of time.

3) The indicator is irreversible.

4) The cost is a penny or less per indicator.

5) It is non-toxic and the materials are FDA-approved.

6) It is extremely small in size.

The device will be extremely valuable to the frozen food purchaser, grocer, and distributor. Its use on pharmaceuticals will also be very beneficial to doctors.

According to Mr. S. L. Dance,[31]

"While the IWI(R) (Irreversible Warmup Indicator) was not developed under NASA contract, the background that led to its development can most certainly be considered as "fall-out" from related NASA activities. The IWI is based on the isothermal melting of eutectic salts or salt hydrates. A knowledge of surface properties, supercooling and nucleation were essential in the development of these devices. This background came in part as a result of such contracts as NAS5-11557 entitled "Design and Development of a Low Temperature Ballon Battery System". The latter contract dealt with the application of similar eutectic salts and salt hydrates to the maintenance of proper battery operating temperatures under extreme environmental conditions. Nucleation of such salts together with supercooling and other problems in salt chemistry and material compatibility dealt with under that contract bear a close relationship to the technology of the IWI.

"The device is currently under study by some 25 companies, each of whom has purchased 500 or more units for evaluation purposes. The Mushroom Co-Operative Canning Company has thus far been our commercial customer, though based on the various tests in progress, we anticipate additional commercial orders in the near future."

This NASA spin-off may prove to be invaluable to frozen food consumers throughout the nation.

4.4 Impact on Epicure Foods Inc.

Epicure Foods is a small company which produces specialized foods products. One of their main product lines is "space foods" which they sell primarily to schools and institutions for testing and experimentation. Many of these food items are based on the NASA-Air Force joint funding of "Space Food Prototype Production Guides" developed for use in making food for the astronauts.[32] Examples of the items sold by Epicure Foods, Inc. are:

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[31] Executive Vice President, Artech Corp., Falls Church, Virginia.

[32] Mr. Norman H. Ishler, Vice President, Epicure Foods Inc., South Hackensack, New Jersey.

Applesauce Mix
Beef Bites
Beef and Vegetable Bars
Brownie Bites
Chicken Bites
Cinnamon Toast Bites
Corn Bars
Fruit Cocktail Bars
Mushroom Soup Powder
Peach Bars
Peanut Butter Sandwich Bites
Potato Salad Bars
Shrimp Cocktail Bars
Spaghetti & Meat Sauce Bars
Spinach Wafer
Toast Bites

Some of these items can be eaten as are, while others must be rehydrated. It should be noted that most of these items are listed in Exhibit 3.4.

4.5 The Use of Chemically Defined, Liquid, Elemental Diets

The chemically defined diets[33] developed by NASA for use on long space missions have been used to feed severely ill patients. Under the NASA studies, researchers evaluated the NASA diets for use as a potential source of food and nutrition for astronauts. The research has substantially increased the knowledge and understanding of the diets. As a result, similar diets have been used in hospitals to nourish severely ill patients.

The hospital diet formulas are based on the experience gained from the NASA diets. Because the diets are extremely nutritious and result in minimal waste, they have been used on numerous patients with abnormalities of the intestinal tract. Without the diets, it would be extremely difficult to maintain the patients in a good state of health. The diets have been used both in pre-operative and post-operative care and also for nourishing premature babies. About two hundred patients have been placed on the diets and as a result, several lives have been saved.

One of the prime users of the diets is the surgeon-in-chief[34] at Rhode Island Hospital. He obtained some slightly altered space diets from

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[33] Discussed in Section 3.5.

[34] Dr. Henry T. Randall, Department of Surgery; also Professor of Medical Science at Brown University.

the researchers who were funded by NASA. He feels that the NASA research was invaluable because it established that the diets were safe and of high nutritional values. If the NASA studies had not been performed, the surgeon would not have felt confident that the diets were not harmful and would not have used the diets so freely. It would have taken a great deal of time to determine whether or not such elemental diets were safe for human consumption.

The use of the diets at the Rhode Island Hospital has led to use of the diets elsewhere. After reading about the life-saving diet, the chief of pediatric surgery[35] at the University of Miami School of Medicine was able to save the life of an infant with the shortest small intestine on record. Small bowel surgery shortly after birth left the infant with less than half the intestine believed to be required for survival. Normal food could not be sufficiently absorbed during the short transit time through the intestine. Use of the highly nutritional diet kept the infant alive for seven months until it was finally able to handle normal food.

The diets have also been used successfully[36] for the treatment of a young girl with severe protein loss. The girl was not maturing normally due to the loss, but finally through the use of the special diets her condition was corrected.

These are only two examples of the many uses that have been made of the diets.

4.6 Impact on Veterans Administration Hospitals

In connection with the food system for the astronauts, it was necessary for NASA to develop a special toothpaste. As a result of the problems encountered during weightlessness, it is necessary for the astronauts to swallow their toothpaste after brushing their teeth. Regular toothpaste contains a detergent which makes it foam. This fact makes it highly undesirable and difficult for swallowing. Under NASA funding, a dentist[37] at the Houston Veterans Administration Hospital developed an ingestible, nontoxic toothpaste, which has received consistent praise from the astronauts.

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[35] Dr. Marc I. Rowe.

[36] Dr. Douglas H. Sandberg, University of Miami School of Medicine.

[37] Dr. Ira L. Shannon.

Here on earth, the toothpaste is revolutionizing the dental care of bedfast elderly patients and handicapped children. These patients typically cannot raise their heads and therefore there is a constant danger that they might choke on regular toothpaste. However, they can easily swallow the NASA toothpaste with no ill effects.

The Veterans Administration makes its own toothpaste (identical to NASA's) at the hospital in Houston and distributes it to 165 other hospitals throughout the United States. In addition, the Veterans Administration has even made an 18-minute movie on how to use the toothpaste, and sends this film to all the V.A. hospitals in the country. The NASA toothpaste has definitely had a very large impact on bedridden patients throughout the nation.

4.7 The Use of Edible Coatings as Temporary Skin

NASA funded the Southwest Research Institute to develop a polypeptide film suitable for an edible food coating. Such a food coating is needed not only to resist bacterial attack and prevent water loss, but also is needed to prevent crumbling of food items. Such crumbs can cause serious problems in the intricate cabin of a weightless spacecraft.

Although the polypeptide film was not very successful as a food coating because of its high tensile strength, the film has since been tested as an artificial and temporary skin. The film is non-allergenic and enables the underlying tissue to breathe. Most importantly, it cuts down on water loss and contamination of serious burns and wounds. These factors are the most crucial to the survival of a badly burned patient. The film has been used on six humans and thus far has probably saved two lives. The major user[38] is at the Baylor College of Medicine, Houston, Texas. He feels that the wound cover is one of the better ones now available and shows considerable promise for the future. Although it does not serve as a permanent skin, it enables the burned patient to survive and recover to the point where permanent skin grafts can be made. The film could prove to be a real lifesaver. In this country alone, each year over

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[38] Dr. Melvin Spira

two million persons are hospitalized for burn wound treatment and of these, about 10,000 die.

4.8 Impact on the Pillsbury Company

The Pillsbury Company has been responsible for producing a number of special food items for NASA, particularly in the area of dehydrated or freeze-dried compressed foods. More recently, Pillsbury has developed pre-cooked, pre-buttered rolls preservable up to 600 days to meet the requirements of current space projects.

Pillsbury feels that significant technological advances were made as a result of its work for NASA. The company has become actively interested in specially preserved and nutritionally balanced foods and safe food production methods. While the general public may not be ready for some of the new items at present, special food markets are expected to develop in time, and this technology should prove beneficial to the food industry as a whole.

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